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For the PC Systems Integrator

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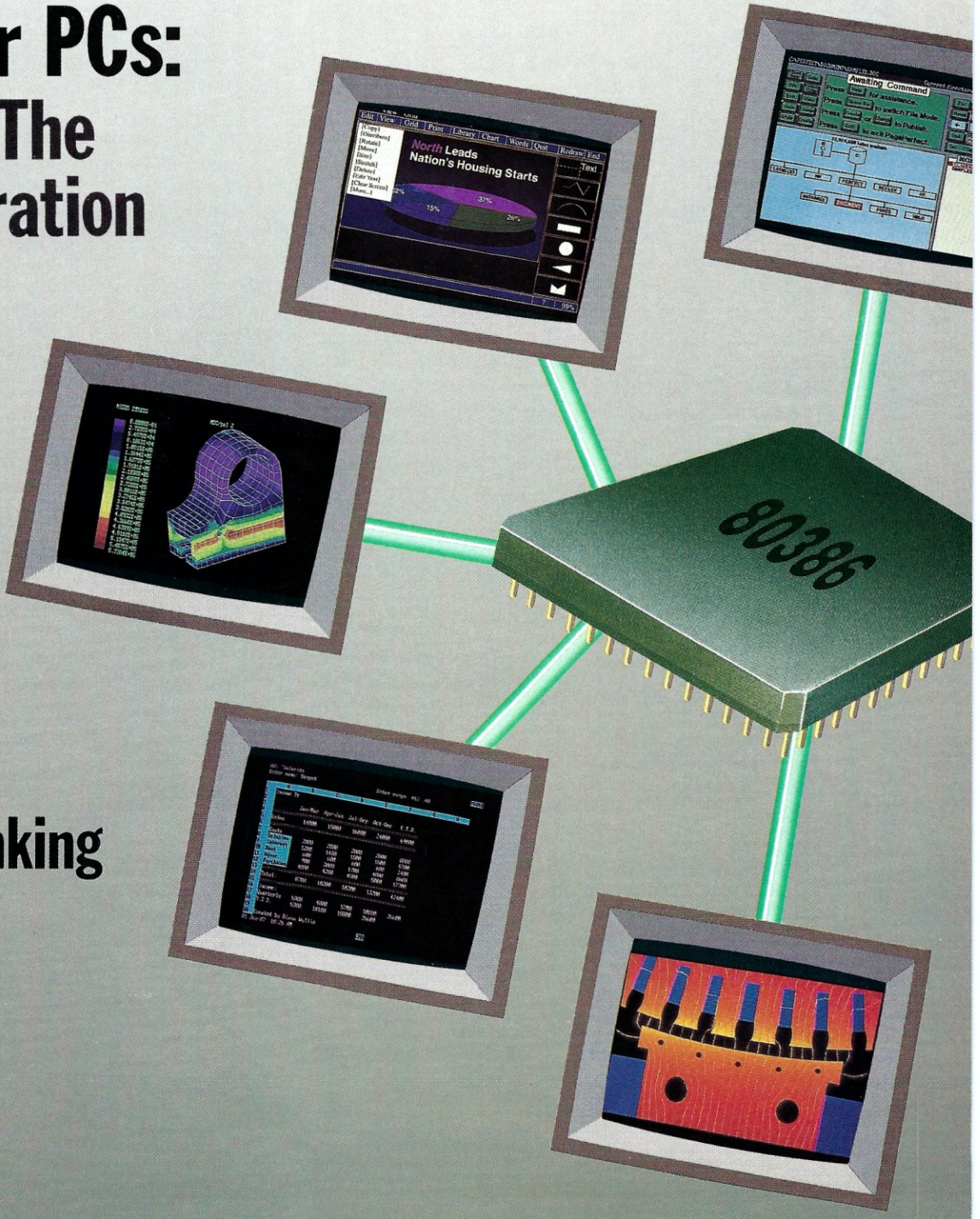

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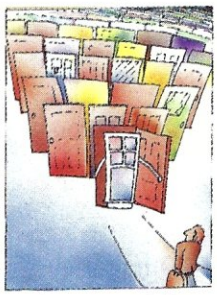

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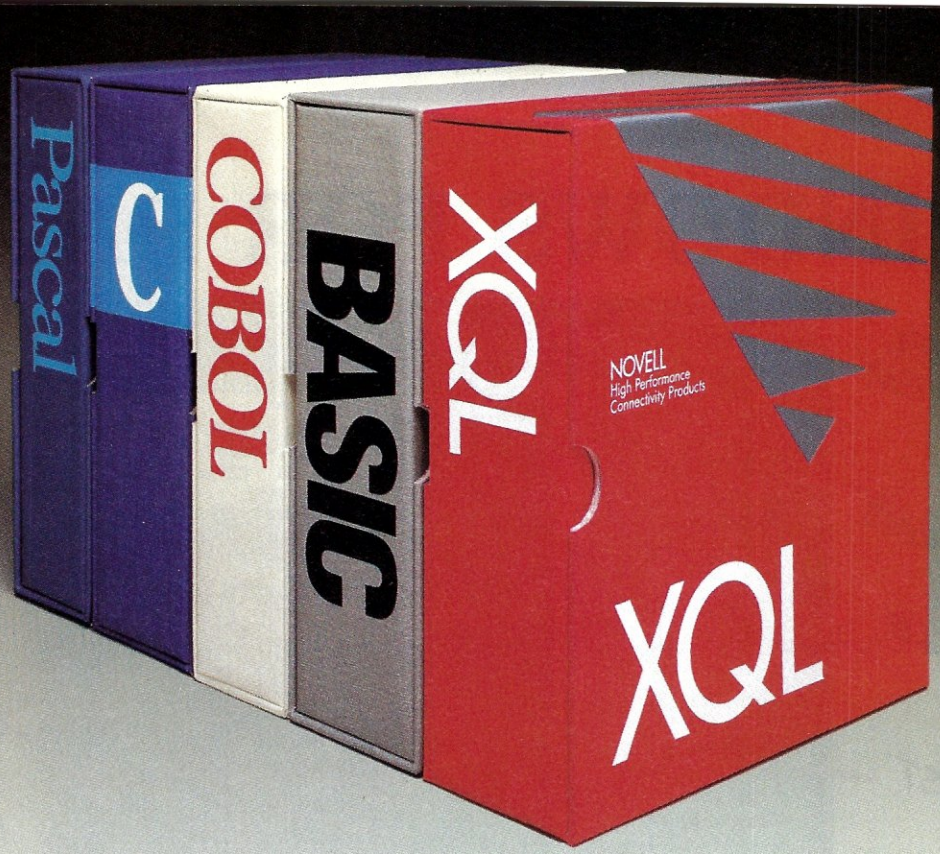

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For the PC Systems Integrator

Micro Systems JOURNAL

May 1988
Vol. 4 . No. 5

FEATURE ARTICLES

Making DOS Multiuser
Although DOS was originally created as a single-user, single-tasking operating environment, running DOS applications under UNIX opens up new multiuser, mutitasking possibilities. In this article, the authors explore these possibilities, and examine new products that bring single-user multitasking to DOS applications in multiuser environments.
by Stephen Randy Davis and Michael Hurwicz 22

Memory Management and EMS
Multitasking programs are gaining wider user acceptance, and consuming more PC memory, so it is becoming increasingly important to properly manage microcomputer memory. Understanding the Expanded Memory Specification (EMS 4.0) can help you maximize PC memory.
by Howard Vigorita 34

Multitasking Under OS/2
How does OS/2 work? This discussion of interprocess communications and dynamic linking helps explain what gives IBM's new operating system its multitasking power.
by George Miller 42

PRODUCT REVIEWS

Multiprocessing with Multilink Advanced
This review offers a look at an operating system enhancement from Software Link that uses statically allocated memory partitions to deliver multiuser capability.
by Howard Vigorita 30

THEOS 286-V Operating System
At last, there is a multiuser, multitasking operating system that makes effective use of the 80286 protected mode and breaks the 640K memory barrier.
by Walter Stagner 48

The Pick Operating System
Dick Pick's approach to operating systems provides power beyond that offered by DOS for entering, storing, and retrieving data.
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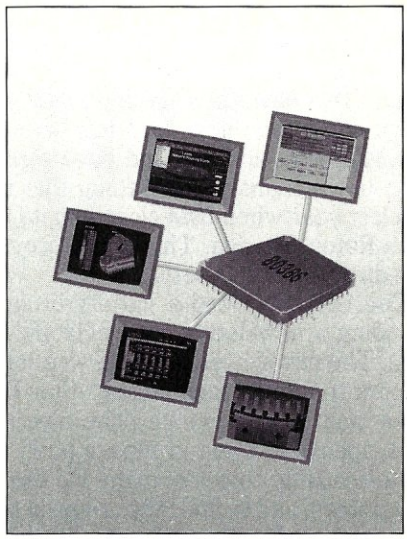

About the cover: Local area networks have been commanding a lot of attention in the integration market, but new advances in multiuser systems provide an effective challenge to LANs in many environments. This issue offers a look at the new generation of multiuser systems, including a discussion of running DOS applications under UNIX, and new hardware, software, and hardware/software solutions to the problem of running single-user DOS applications in a multiuser, multitasking environment. Also offered are reviews of two innovative approaches to multiuser operating systems.
Cover art by Frank Pollifrone

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Micro/Systems Journal (ISSN 8750-9482) is published monthly by M & T Publishing, Inc., 501 Galveston Drive, Redwood City, CA 94063; (415) 366-3600. Second-class postage paid at Redwood City and at additional entry points. **POSTMASTER:** send address changes (form 3579) to *Micro/Systems Journal*, Box 3713, Escondido, CA 92025. **Change of Address:** Please send old label and new address to *Micro/Systems Journal*, Box 3713, Escondido, CA 92025. **Customer Service:** For subscription problems, call: (800) 321-3333; In California call (619) 485-9623. **Subscription Rates:** U.S., $29.95 for one year, $56.97 for two years. Canada and Mexico add $17 per year for airmail, $7 per year for surface mail. Other countries add $28 per year for airmail.
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From the Editor's Desk

Is IBM Slipping From Its Leadership Role?

For many years, IBM has driven the computer marketplace and determined its future. That now appears to be a thing of the past. It is now the software developers who are setting the pace.

For some time now, IBM has been retrenching and software suppliers like Microsoft and Borland have significantly increased their leadership roles in the industry. The thing that really brought this fact home to me was last year when IBM closed up its User Support Group (USG) based in Boca Raton, Florida. This group provided support to PC user groups and also directly to PC users.

The USG provided a variety of support services to PC user groups, including a newsletter, an electronic bulletin board, and a speakers' bureau. The newsletter, *Update*, was sent to several hundred PC user group officers to inform them about other PC user groups' activities, USG services, and special events. The electronic bulletin board had a message base, special-interest groups, a public domain software file base, and machine-readable copies of many PC user group newsletters. Programmers, integrators, and technically oriented users heavily rely on user groups and bulletin board systems for support. IBM's recognition of this fact, and their support of these services, contributed much to the success of the PC and PC-DOS.

IBM's USG also published a monthly PC users' magazine that was distributed, free-of-charge, via PC user groups. This magazine, which typically ran about 50 pages an issue, contained reprints of worthwhile articles from many PC user group newsletters and technical articles from IBMers in the Entry Systems division. It was a very worthwhile publication. The USG also maintained an electronic bulletin board system that could be accessed by any PC user via an 800 number.

Although, IBM closed down the PC-USG operation in Boca Raton early last year, the IBM PC-USG still exists, but in name only. It no longer offers any of the services it used to offer. Instead, it now just sends out an occasional new products announcement.

Meanwhile, software vendors like Lotus, Microsoft, and Borland have stepped up their PC user group support activities. All of them provide speakers and other services to local user groups. Microsoft, for example, flew PC user group officers to its facilities in Redmond, Washington, last year for a two-day presentation of new products and meetings with key software development and marketing people, including Bill Gates. Lotus has run special meetings for club officers at several locations across the country and shipped 1-2-3 support software utilities and applications for PC user groups to give to their club members. And many of these companies have started magazines for their users. Most also offer support via telephone and bulletin board systems such as CompuServe, and some have set up regional support offices.

These companies deserve a pat on their backs for their recognition of the valuable role user groups play in the microcomputer industry, and for their support of them. They are also to be complimented for their efforts to provide support for individual users. IBM still provides support to its larger corporate accounts, the accounts to whom it sells direct, but the individual IBM user is now out in the cold. As for IBM's leadership position in the industry. . . . What can one say? It is now a thing of the past.

Sol Libes

For the PC Systems Integrator
Micro Systems JOURNAL

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Micro/Systems Journal (ISSN 8750-9482) is published monthly by M & T Publishing, Inc., 501 Galveston Drive, Redwood City, CA 94063; (415) 366-3600. Second-class postage paid at Redwood City and at additional entry points.

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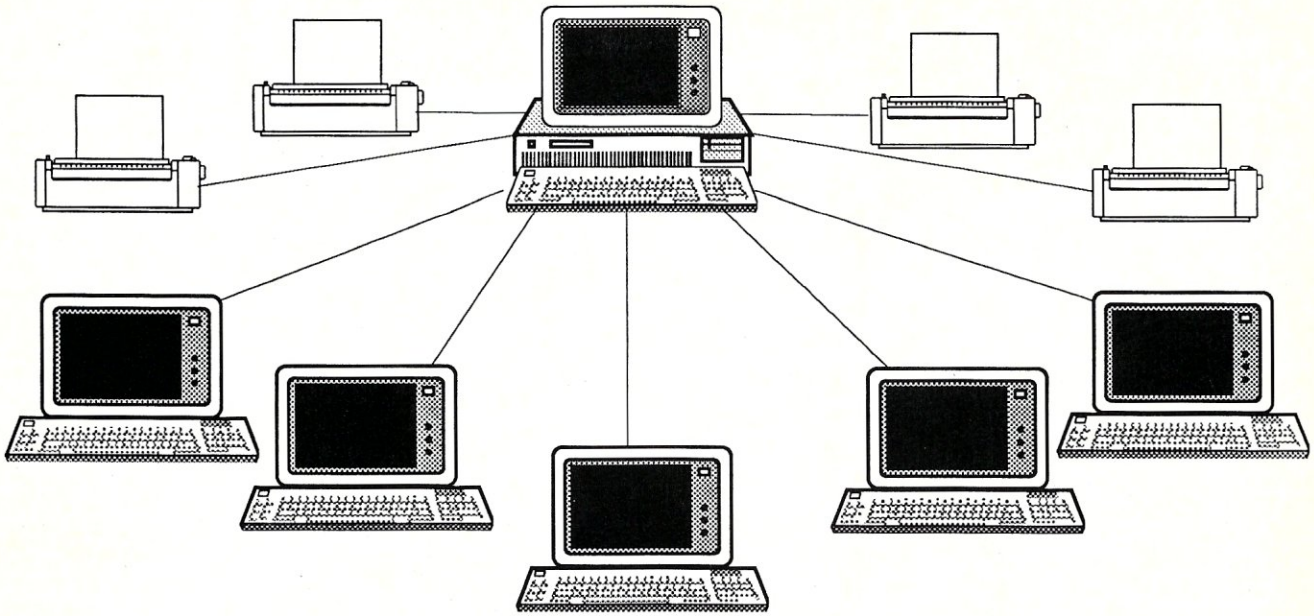

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News & Views

by Sol Libes

Random Gossip & Rumors

Intel is rumored to have early silicon samples of its 80486 chip up and running soon, and expects to ship samples to key customers late this year. Limited production may begin late next year. That's just about the right time since the 386 will at that time be about four years old and starting to show its age.

Intel is expected to shortly release two new versions of its 386 motherboard, both of which offer substantially improved performance. Many PC-compatible builders use the Intel motherboard, which has an AT form factor, in their 386-based systems. One version will sport a 25-MHz processor and 64–KB cache, the other will use a 20MHz chip and 16–KB cache. Both will contain two 32-bit slots as well as five 16-bit and one 8-bit slot, and each will be capable of having as much as 8 MB of RAM on the board (using 1 MB chips). Intel is boasting that the new boards will offer twice the performance of its current board.

"Street prices" for **IBM** PS/2 models are now down to 35–40 percent off list. These steep discounts reflect recent increases of IBM dealer quotas and dealers' need not to let inventory build up.

OS/2 Update

There are rumors that **IBM** will again push back the delivery date for OS/2 Version 1.1 containing the Presentation Manager. When OS/2 was originally announced in April of last year, IBM promised to ship it this coming August. When IBM released Version 1.0 in December, it pushed back the date to October. Alpha copies were shipped to a few select OEMs in February and as yet there is no word on when software developers copies will be shipped. If Version 1.1 follows the same cycle as Version 1.0, don't look for it until the end of the year at the earliest.

The Extended Edition of OS/2, which will be an IBM proprietary product, is promised for November delivery. Rumors are that it will be furnished on 16, 1.4-MB, 3½-inch floppies—that's over 23 MB of object code, making it even larger than any of the versions of UNIX for the PC (which is multiuser) as well as multitasking, and includes all sorts of developers' tools.

At a recent seminar, **Microsoft** CEO Bill Gates predicted that by 1989, 15 percent of "new" PCs would be running OS/2, and that number would grow to 50 percent by 1991. However, some software developers are questioning whether OS/2 isn't half an operating system.

Early reports from systems integrators indicate that many are attempting to install IBM's version of OS/2 on AT-compatibles, with a high degree of success on 286-based machines. 80386-based systems with "enhanced BIOS" ROMs are proving more difficult, however.

Some OS/2 software applications have reportedly run into problems running on different implementations of OS/2. The problem appears to be related to the different peripheral drivers and memory configurations being used.

Microsoft shipped its OS/2 Software Development Toolkit to OEMs and software developers in early March, about three months behind schedule. Despite Microsoft's promise that a beta version of the LAN Manager would be included with the package, it was not there. Microsoft claimed that it was adding some development tools and would release the Toolkit in July. However, based on Microsoft's track record, I would not look for it until the fall.

DOS Rumors

Despite denials to the contrary, look for **IBM** to release PC-DOS Version 4.0 in the near future. It is expected to be introduced as the primary operating system for its new laptop computers (see "News & Views," *Micro/Systems*, April 1988) and also be made available for desktop systems.

New enhancements should include a user-friendly shell with pull-down menus that supports a mouse input, built-in support for IBM's proprietary XMA extended memory specification, larger hard-disk partitions, and higher resolution displays. Microsoft will no doubt follow that with similar upgrades to MS-DOS. Actually some of these features have already appeared in DOS versions from Compaq and Zenith.

There is also word that Microsoft is trying negotiate an MS-DOS license with the Soviet Union. However, it has encountered two problems: First, the USSR does not have copyright protection for software. Second, the Soviets already have developed their own DOS-compatible operating system.

MCA Features Where Are You?

The Multi-Master Architecture (MMA) of the PS/2 MicroChannel Architecture (MCA) was touted by **IBM** as the circuitry that would do the most to enhancing system performance. The MMA would enable master (as opposed to the slave-type currently in used) plug-in cards to operate on the MCA bus. A prioritized arbitration scheme would let intelligent board masters take over the channel and directly access other boards or memory without going through the main processor, resulting in faster throughput.

It is interesting to note that 12 months have passed since IBM's introduction of this architecture, and as yet we have not seen a single plug-in board product that uses the MMA technology. Even IBM, the designer of the MMA, has yet to introduce a product that utilizes the MMA.

Another interesting item is that the old S-100 bus standard had an MMA that could arbitrate among as many as 16 bus masters—the point being that MMA is not new (it has also been implemented on the Intel Multibus). In fact, the S-100 bus standard written almost 10 years ago includes a suggested circuit for the MMA arbitration.* Yet, I do not know of any manufacturer that designed and marketed an S-100 board using the MMA architecture.

The PS/2 Model 50 contains four MCA slots, of which three are available for MMA operation. The Models 60 and 80 contain eight MCA slots, with seven available for MMA operation. And, although the Model 80 uses a 32-bit processor (80386), it provides only a 16-bit-wide data path on the MCA for MMA operation.

There is speculation that there are problems with IBM's implementation of the MMA. Further, the software to manage bus control transfers is difficult to write. And some contend that it is easier to put a complete processor system on a board that operates independently of the MCA bus.

In the meantime, several 286/386 system manufacturers are demonstrating that their systems can provide greater throughput than the IBM MCA-based systems using enhanced versions of the old AT bus. □

---

* *Interfacing to S-100/IEEE-696 Microcomputers* by Sol Libes and Mark Garetz contains a 20-page chapter on the subject of Multi-Master Architecture operation, including details about the needed circuits for managing MMA operation. The book has been recently revised and reissued by M & T Publishing.

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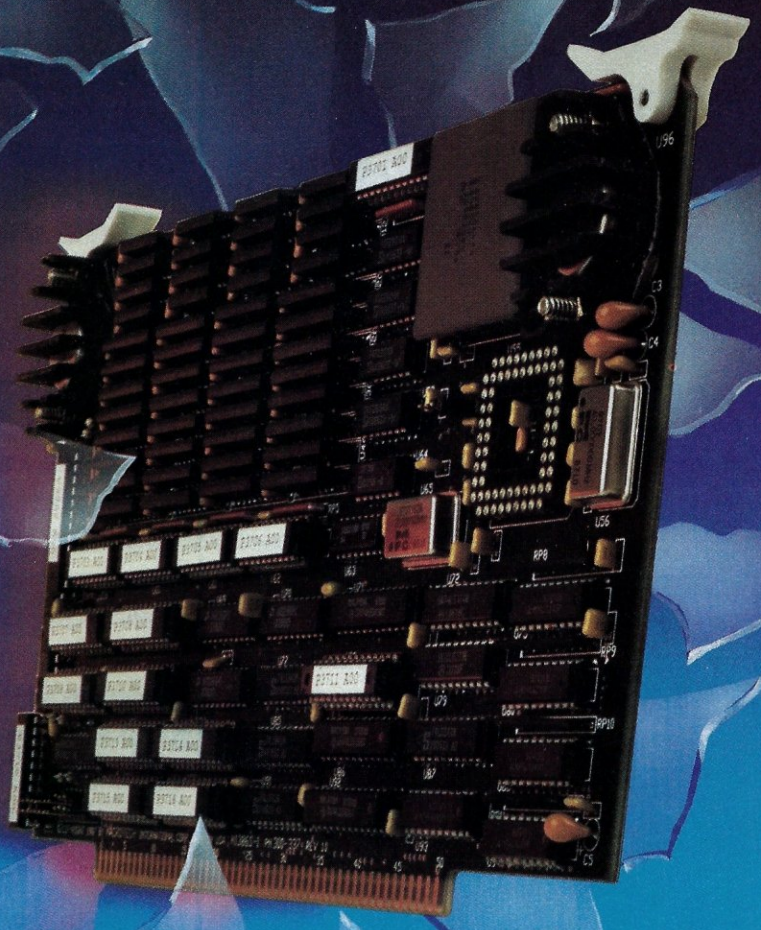

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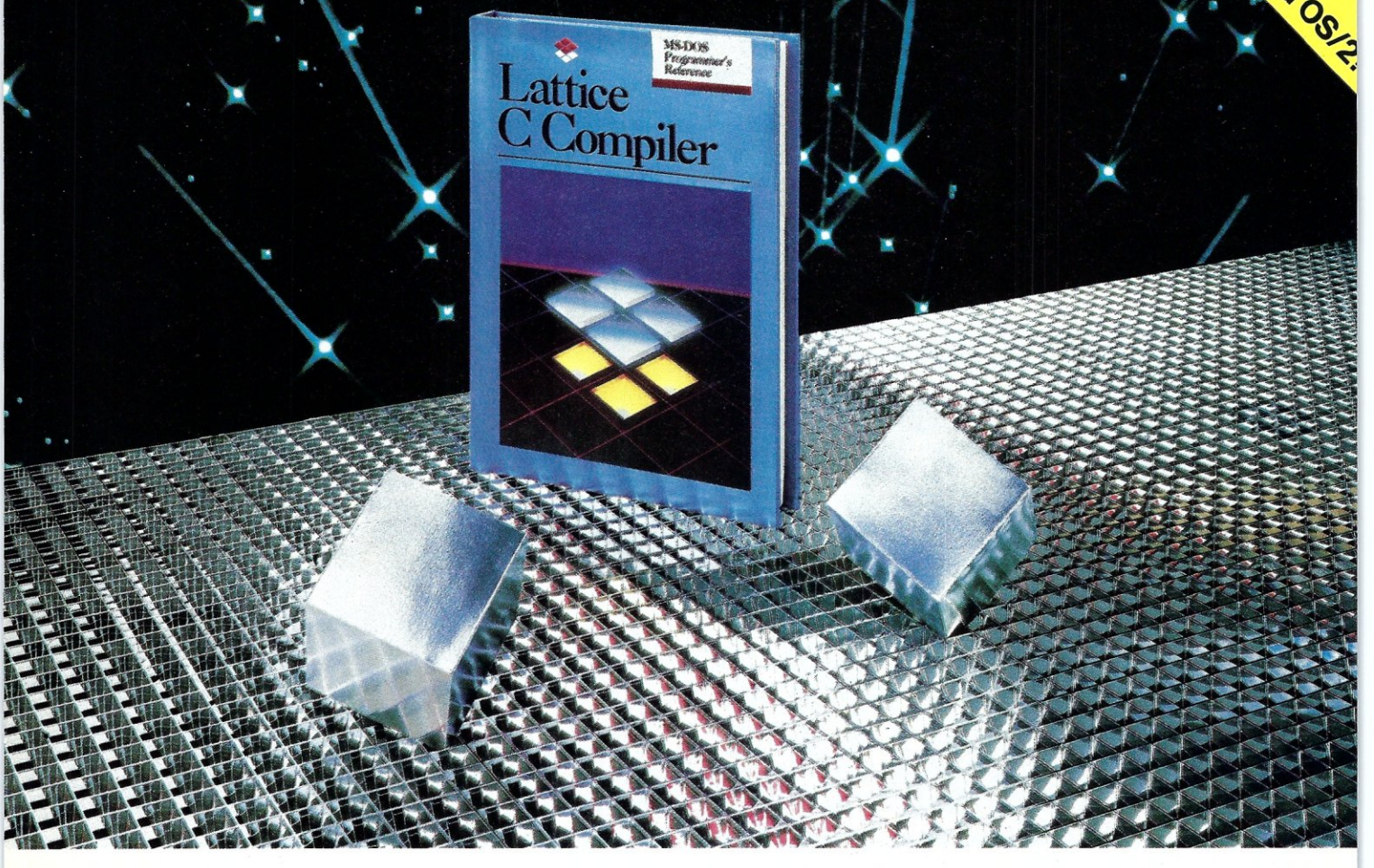

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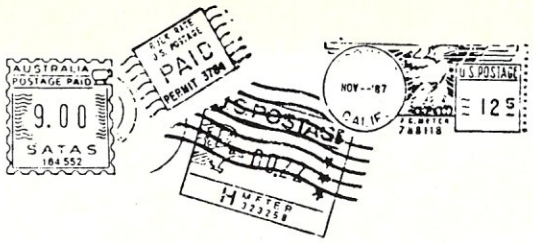

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Security Exposure in DOS 2.x

To the Editor:

There is a security exposure in PC-DOS 2.x versions of FORMAT. By simply formatting a diskette, you could be giving away up to 490 bytes of sensitive information. The problem is that on double-sided diskettes, DOS only uses 22 bytes in the second sector of the File Allocation Table (FAT). The remaining 490 bytes contain whatever was previously in RAM. I discovered the ASCII records from my accounting file on one such freshly formatted diskette. This was information I would rather not see handed around on my diskettes.

However, you have to resort to some fairly exotic methods to look at these sectors. Remember that we are not dealing with a "file," but rather sectors in the control area reserved by DOS. To explore what you are giving away on that diskette, enter the following DEBUG commands:

```
L100 0 2 1 for Drive A, Logi-
           cal Sector 2, 1
           sector
D100       look at the sector
```

This will load the second sector of the FAT and display it. What you see may be part of a program or some data from a previous use of the computer disk. As a simplification, if the text shown on the right side of the screen is not intelligible, i.e., random-looking characters, then you are probably safe(?) since it would take a software expert to decipher the data. If it was a Lotus worksheet, I could tell you the cell numbers and their contents.

Note that DOS Version 3.0 to 3.3 clears the FAT sectors completely. A diskette "fresh out of the box" or one subjected to WIPEDISK has the same opportunity of receiving your sensitive data during a FORMAT process. One secure answer is to reboot the computer. An easier approach is to run CHKDSK to fill the memory with FAT sectors from your fixed disk (if you have one). This will guarantee that what you are giving away is not your own data.

It's a little late in the life cycle of DOS 2.x to be worried about those 490 bytes on your diskettes, but there are a lot of DOS 2.1 systems out there. Take a look; it might be frightening.

Grey Staples, CDP, CCP
Information Repair Service, Inc.
Scottsdale, Ariz.

In Search of Meaningful Benchmarks

Dear Editor:

A.G.W. Cameron's column, "The Scientific Computer User," is a useful source of information (and rumors) not available elsewhere, and is must reading. I regretted the lack of recognizable benchmarks on real problems in your previous columns, so I don't mean to criticize your attempts to include them (see "Number-Crunching Coprocessor Boards," *Micro/Systems,* February 1988, and "Mini-supercomputers on the Desktop," *Micro/Systems,* March 1988). I find the numbers quoted confusing after my extensive experience with Sun and Multiflow computers using the Weitek 1164/6 and 2264/5 chips.

The Sun 3 workstations can easily exceed the quoted Linpack performance on real problems; the Linpack problem itself is solved at 0.8 mflops single and 0.63 mflops double with improved accuracy using the Crout scaled partial pivoting algorithm on the Sun 3/260 or 3/280. There is a loss in accuracy going from the 6881 coprocessor to the 1164/5, typically losing 2 bits of single precision. If care is not taken to prevent the Sun compiler from converting expressions like x(j)/y to x(j)*(1/y) (as all Cray compilers do), another 2 bits of precision may be lost on the 1664/5, which are relatively slow in division and extremely slow on SQRT. The single most-needed improvement in the Weitek chips would be on a SQRT that would have full accuracy and reasonable speed.

The reason for improved accuracy of typical computations on the 68881 is, of course, the higher precision used for register variables, which are selected only if the -P or -O options are specified for FORTRAN or the variables are declared "register" in C. Double-precision calculations without register variables are less accurate on the 68881 in some cases, presumably because of the double rounding, first to 64- and then to 53-bit precision.

On the other hand, the mini-supercomputers seem to be designed to produce better performance on Linpacks, without regard to accuracy. I wonder whether the Sun 4 is really so much faster than the Sun 3, as the Linpack claims. The fastest credible Linpack compiled from FORTRAN that I know of for a single WL2264/5 chip set are obtained on Multiflow, which is rated at 6 mflops double, at the expense of accuracy. Normal "vectorizable" programs run 3 to 4 mflops on the Multiflow, which is not bad considering that many scalar computers do not approach Linpack speed on such code. This speed can be sustained during evaluation of transcendental functions; however, the rating is somewhat spurious as almost twice as many multiplications are used when pipelining power series evaluations, as would be required on a scalar computer.

I went through your discussion of mini-supercomputers in the hope that some way would be offered to improve benchmark claims, not to deny that Linpack is one of the best widely accepted benchmarks. I have difficulty believing claims of 10 to 13 mflops double-precision on current technology Weitek chips, although it may be possible with hand coding in assembler.

With the probability that 80386/7 machines will fall to PC prices when the scarcity factor is overcome, I am sure I am not alone in wondering when, and in which direction to take a plunge. Sun workstations appear to have sufficiently better graphics and integrated software to justify the somewhat higher price (more than "somewhat" for Weiteks), but the individual worker can hardly expect support on bug fixes when Sun won't provide support for installations of three dozen workstations with full maintenance contracts.

Dr. Timothy C. Prince
Birmingham, Mich. □

February Correction

The computer industry moves so fast that we often can't keep up with it. We inadvertently listed the old address for Meridian Technologies, manufacturer of Carbon Copy, in the February "LANscape" column. The company's new address is:

Meridian Technology
7 Corporate Park, Ste. 100
Irvine, CA 92714
(714) 261-1199

by Don Libes

More on the International Obfuscated C Code Contest

Last month, I presented the winners of the 1987 International Obfuscated C Code Contest (IOCCC). In the past, a lot of people have asked me to explain some of the programs, or at least say what they do. While they make pretty wall-hangings, photographs of them are simply not acceptable to computers. Surprisingly, most of them have useful functions.

This month's column presents descriptions of what each winning program does, and explains some of the simpler ones (read, the ones I understand). Unfortunately, there is not enough space to run both this column and all the programs, so please fetch last month's *Micro/Systems* so that you can see the programs.

First, we will warm up with the simplest and shortest program. In the category of the "Best One Liner" was David Korn of AT&T Bell Labs, Murray Hill, New Jersey, with this winning entry:

```
main() { printf(&unix["\021%six\012\0"],(unix)["have"]+"fun"-0x60);}
```

First, we must read the judge's remarks: "Compile on a UNIX system, or at least using a C implementation that fakes it." This cryptic remark refers to the use of the symbol *unix*. This symbol is commonly *#defined* to be 1 on UNIX systems. Even if you don't program on UNIX systems, you should be familiar with the common preprocessor macros, because many people take UNIX source and compile them on non-UNIX machines without change.

```
main() { printf(&1["\021%six\012\0"], (1)["have"]+"fun"-0x60);}
```

Editor's note: the ↷ symbol denotes that, due to space limitations, this line of computer code had to be continued on the next line. Please input as a single line of code.

Remove the parentheses from around the *1*.

```
main() { printf(&1["\021%six\012\0"],1["have"]+"fun"-0x60);}
```

Subscripting is defined in terms of pointer arithmetic. In particular, *1["have"]* is equivalent to **(1 + "have")*. Performing a similar substitution on the other subscription, we have:

```
main() { printf(&*(1+"\021%six\012\0"),*(1+"have")+"fun"-0x60);}
```

Remove the constant *1* from both expressions.

```
main() { printf(&*("%six\012\0"),*("ave")+"fun"-0x60);}
```

Remove the *&** and the unnecessary parentheses.

```
main() { printf("%six\012\0",*("ave")+"fun"-0x60);}
```

Execution of **("ave")* returns the character *'a'*.

```
main() { printf("%six\012\0",'a'+"fun"-0x60);}
```

'a' has the value of *0x61*.

```
main() { printf("%six\012\0",0x61+"fun"-0x60);}
```

Remove the constants *0x61* and *0x60*.

```
main() { printf("%six\012\0",1+"fun");}
```

Rewrite *1+"fun"* as *"un"*.

```
main() { printf("%six\012\0","un");}
```

Substitute *"un"* as the string to be formatted in the *printf()*.

```
main() { printf("unix\012\0");}
```

\012 is interpreted as a new line, with the result that our terminal prints out:

```
unix
```

In the category of "Best Obfuscator of Programs," the winner was Paul Heckbert of Pixar.

This program is like a C-smart version of the Berkeley "fold" program. It takes one argument that is the maximum length of the output line. The standard input is then read and "folded" so that lines will not run over the given line length.

This program has sufficient knowledge of how to preprocess and scan C programs so that it can "fold" them without breaking up tokens, literals, or anything else. Comments are recognized and removed.

What this program does is useful, but probably only to the IOCCC judges since it is sensitive to C programs and most people don't write lines greater than 80 characters.

In the category of "Most Useful Obfuscation," the winner was Larry Wall of Unisys—System Development Group of Santa Monica, California.

A quick glance at this program told me it was going to have something to do with Roman numerals. I had a little trouble compiling it because my compiler insisted that *c=cm=++I* was syntactically incorrect. It apparently was treating the *=+* as a token. *=+* was the original syntax for the *+=* operator, and it appears as though the scanner still recognizes the token, if only to say that it is a syntax error. I solved the problem by putting in some white space between the two characters.

Following the judge's comments, I figured out what it was supposed to do. Namely, it converts Arabic to Roman. However, if it gets input from a pipe (or anything that isn't a *tty*), it converts from Roman back to an Arabic mathematical expression. The UNIX *bc* program takes it the rest of the way. Finally, if its output is directed to a pipe, it converts Roman to Arabic.

The judges suggested executing the following commands:

```
lwall ¦ bc ¦ lwall      (I typed)
x*x                     (me)
c                       (system)
c^2                     (me)
mmmmmmmmmm              (system)
```

What was happening was that *lwall* was converting *x*x* to (10)*(10). *bc* converted that to 100, and *lwall* took that and produced *c*. A similar production occurred in the second example.

Unfortunately, I found this program was UNIX-specific. I hope no one spent too much time with it unsuccessfully because of that. There were certainly enough other mysterious things about the program to ponder.

The most unusual part of the program was the use of *signal()*. The program created a pipe, closed one end, and then proceeded to generate illegal pipe writes all over the place. The author called *signal()* whenever he needed to jump to a new routine,

establishing a new signal catcher. Then he would call *write()*, which would (almost) always fail, entering the signal catcher.

In the category of "Best Layout," the winner was Brian Westley of Starfire Consulting, St. Paul, Minnesota.

Like the preceding program, I assumed this would have something to do with palindromes. I was right. It printed out the string:

```
Able was I ere I saw elbA
```

(A fitting output for such a symmetrical program.)

The program itself is uninteresting, other than noting that it prints out the string backwards (which, of course, is unnoticeable because it is a palindrome).

In the category of "Best Abuse of the Rules," the winner was Mark Biggar, Unisys—System Development Group, Santa Monica, California.

I hope everyone figured this one out. It was an exercise in substituting preprocessor definitions. (The compile line was *cc -DC="R>0" -DI="if (T)O" -DO="c=write(1,&c,1);" -DP="main(){X}" -DR="read(0,&c,1)" -DT="c!=015" -DW="while(C)I" -DX="char c;W" markb.c)*

```
P;
main(){X}
main(){char c;W}
main(){char c;while(C)I}
main(){char c;while(R)0)
if(T)O}
main(){char c;while(read
(0,&c,1))0)if(c!=015)c=
write(1,&c,1);}
```

Once you get this far, it is obvious what the program does; it copies its standard input to its standard output (except for carriage-returns).

In the category of "Worst Style," the winner is Spencer Hines of OnLine Computer Systems, Hyattsville, Maryland.

Here was yet another program whose subject matter I could predict. On the other hand, what it was going to do with it I hadn't a clue. Taking the judge's hint, I did the following (after compiling it and naming it *avalon*):

```
avalon avalon.c
24    goto   's
```

Not particularly useful, but very cute. Unfortunately, its own output gives some indication of the internal structure of the program. It resembled poetry—each set of two lines was a statement followed by a *goto*. Some of the statements had *goto*'s in themselves. Once the *goto*'s were removed, the program revealed itself to be a straightforward piece of code that simply counted all the occurrence of the string *goto* on each line.

And the grand prize for "Most Well-Rounded Confusion" goes to Roemer B. Lievaart of VU Informatica, Amsterdam, The Netherlands.

I looked at this program for a while, but eventually gave up in disgust. The judges definitely gave this award to the right program. I never was able to figure out what it did by myself, let alone how it did it.

Fortunately, the author included the following with his submission:

> This program plays the game of Reversi (Othello)! Compile and run. First, it asks for a playing level. Enter 0–10 (easy–hard). It then asks for your move. A move is a number within 11–88, or a 99 to pass. Illegal moves (except for an illegal pass) are rejected. Then the computer does its move (or a 0 to pass) until the board is full. It plays rather well for such a small program! I had to leave out the board-printing routine, so you'll have to take a real game board to play it. Also, due to space-limitations, I took out the passing-handler, which makes its ending-game rather poor. But it does know all the rules, it uses alpha-beta-pruning, and it plays f.i. on mobility(!). Most important: *it can play a pretty good game of Reversi!*

This year's contest was great. I am continually amazed at the quality (or should I say opacity) of C code that is submitted. And, if this is any reflection upon the general practice of C programming, I can rest assured that I never have to worry about finding a job (a real job that is). I wish you all good luck in next year's contest. The rules were printed in last month's column, so please refer to it if you have questions. □

Don Libes is a computer scientist working on artificial intelligence in robot control systems in the Washington, D.C., area.

All the source code for articles published in *Micro/Systems* is available on an MS-DOS disk. To order, send $14.95 to *Micro/System Journal*, 501 Galveston Drive, Redwood City, CA 94063; or call Tim at (415) 366-3600. Please specify the issue number. Source code is also available on CompuServe; type GO DDJFORUM.

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by Stephen R. Davis

Virtual Memory Techniques: Part 3—Conclusion

In the previous two columns I have been building up to implementing a Virtual Memory Manager (VMM) in Turbo Pascal. In the March column, I discussed what a VMM is and how it's used. In last month's column, I looked at a simple function which, by returning the address of an array, could be used in expressions such as:

```
Pdata (I)^[J]
```

which looked and functioned similarly to the conventional matrix reference:

```
Mdata [I][J]
```

Now, I am finally ready to examine a "real" VMM (Listing 1). The program allows the user to define a data structure of any size up to the available disk space in the host computer. This data structure must be divided up into "blocks" of some sort, each of which must be smaller than 64 kilobytes. Usually these blocks are suggested by the data structure itself. For example, each of the rows of a matrix may be considered a different block.

Blocks are numbered sequentially beginning with 1. Having initialized this data structure using the *InitData* procedure call, the user program may then reference these blocks using the *Pdata* procedure. Thus, *Pdata (I)* returns the address of the I'th user block. If this were, in fact, the row of a matrix then *Pdata (I)^ (J)* would reference the J'th element of the I'th row, exactly as if the entire matrix were loaded into memory. If the user data block were some user record, then individual elements would be referenced using *Pdata (I)^.*.

To understand the program, begin with the two record definitions, *DataBlock* and *FreeBlock*. A *DataBlock* exists for every block of user data. Contained within this record is the segment indicated where that block is loaded in memory, *DMemSeg*, and the location of that block in the data file containing the user data on disk, *DiskAddr*. If *DMemSeg* for a particular block is zero, then the data block is not currently loaded in memory. *DiskAddr* is always defined for every block, since each block must have a space in the data file reserved for its specific use.

A *FreeBlock* record exists for every block of RAM available to the VMM for storing data. Free blocks must be of the same size as data blocks, but they may be much fewer in number. The *FMemSeg* element contains the segment address in RAM of the *FreeBlock* while *DataIndex* is the index of the current *DataBlock* that occupies it. A *DataIndex* of zero implies this memory block is not in use by any data block.

The main program is nothing more than a small routine designed to test the VMM. The call to *InitData* asks the VMM to initialize roughly 128K of user data (1000 × 128 byte blocks) and 12.8K of RAM (100 × 128 byte blocks). *InitData* creates a disk file, DATA.TMP, 128K long and writes dummy data into each block. It then initializes 1000 *DataBlock*s and 100 *FreeBlock*s. *InitData* gets its free RAM from the heap. If there is not enough heap available to honor the request, the program aborts.

Having initialized the VMM, the test program then writes test data into each word of each data block. With each call, *Pdata* fetches the segment address of the block specified by the caller's index. If it is non-zero, then the block is already in memory and *Pdata* simply returns the address (called a "hit"). If the segment address is 0 (a "miss"), then it must be loaded into RAM from DATA.TMP.

Pdata begins loading a data block from disk by looking for an unused free block in which to store the data with procedure *FindFree*. *FindFree* simply loops through all of the virtual memory blocks until a free block is found. If no free RAM blocks exist, then a data block must be written to disk to free up a RAM block for use. There are several algorithms for deciding which block to choose. I chose a very simple one, I just keep a pointer and increment it each time a record is purged.

The procedure *Unalloc* actually writes the RAM block to disk. It then erases the *DataIndex* in the *FreeBlock* and zeroes the *DMemSeg* so the program will know that the data block is no longer in memory and that the RAM block is available.

Pdata stores the user data block into this RAM block by calling *Alloc*. *Alloc* first stores the segment address in the *DataBlock* and then its *DataIndex* into the *FreeBlock* record. Finally, it reads the data from DATA.TMP into memory. *Pdata* fetches the new segment out of the *DataBlock*.

Pdata converts the segment address into a two-word memory address using the intrinsic function *Ptr* and returns this to the caller.

Once the data blocks have been initialized, the test program begins to randomly access the data blocks to test the VMM. Data block indices are generated by calling the function *Random*. On each reference, the first two locations are printed out to verify that the data is intact. The index of the current reference is placed into location 2 so we will know when this row was previously referenced, if at all, on subsequent accesses. The range of data indices can be adjusted by changing the call to *Random* up to a maximum of the number of data blocks (1000).

The final call to *CloseData* allows the VMM to purge all data blocks out to disk and close the data file before exiting. The user program may itself call *Purge* at any time to force data out to disk.

Two sets of debug statements exist to help inform the user what the VMM is doing. Defining the label DEBUG before compiling will cause *ReadBlock* and *WriteBlock* to print the index of each *DataBlock* read or written to the screen. Anyone seriously attempting to study this program should do this and study the resulting output, especially during the random-access phase.

In actual use, it is not necessary to know the actual block numbers, but it is still interesting to know when VMM hits and misses occur. Defining the label SHOWMISS will cause *Pdata* to place an asterisk on the screen every time a miss occurs forcing the VMM to go to the disk.

Several additional points should be mentioned. First, this VMM uses the disk to store data blocks when they are

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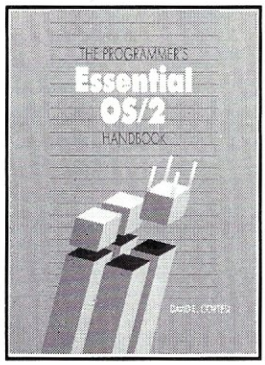

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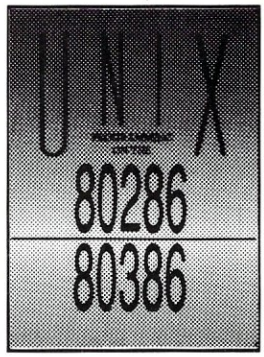

by Alan Diekman

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not in RAM. The storage routines have been written separately to make it possible to adapt the program to any other storage medium. For example, LIM memory could be used just as easily; *ReadBlock* would make the necessary LIM call to access the proper extended block, then move the data from the LIM block into the conventional *FreeBlock*. *WriteBlock* would reverse the procedure; a RAM disk of sufficient size can be used to store DATA.TMP without any changes.

Secondly, the VMM assumes that the data is created within the program itself. If the data already exists in a disk file when the program starts, as would be the case with a word processor or a database application, then the VMM should access the data directly from that disk file. Merely supply the proper file name in *InitReadWrite* and change the call to *ReWrite* to a call to *ReSet* to use an existing file instead of creating a new file.

When the data is not modified by the application, it is not desirable to write data blocks out to the file.

Not only does this speed up VMM initialization, but it can simplify the user code considerably. In this case, however, you must be sure to call *CloseData* before exiting the program to allow the VMM to flush all data blocks to disk and properly close the file. In addition, the user program should call *Purge* after especially critical operations to make sure that important data is written to disk in the event of a power failure.

In some applications, the data is not modified by the application. A common example is text files containing help information. When this is the case, it is not desirable for the application to write these data blocks out to the file as they are purged from memory, since this merely wastes time. Instead, comment out the call to *BlockWrite* (in addition to the changes already noted).

Finally, notice that *FreeBlock* RAM is only limited by the amount of available conventional RAM in the host and is specifically not limited to 64K. The maximum number of *DataBlock*s is 16000 (64K divided by 4 bytes per record). Each data block is limited to 64K for an overall maximum user data size of roughly 1 gigabyte. Actually, under Turbo 3.0 data files larger than 64K * 128 bytes or roughly 7.6 MB cannot be accommodated. However, a simple modification to the VMM could allow it to divide data among several disk files.

The VMM program discussed here is written for Turbo 4.0, but can be executed under 3.0 if the following simple modifications are made:

1. Remove all of the conditional compilation statements; either insert the statements without the conditionals or remove the line entirely. (Conditionals are interpreted as bogus include file statements under 3.0.)
2. Define a new variable TEMP of type ADR and replace *Pdata(I)^* with *TEMP := Pdata(I)* followed by *TEMP^*, for example:

```
Pdata(I)^[J]  ==becomes==>
   temp := ↷
      Pdata(I);temp^[J]
```

. . . continued on page 20

Listing 1. Virtual Memory Manager for Turbo Pascal 4.0

```
Type
    dword = integer;        {define the type of data}
Const
    dsize = 2;              {size of 'dword' in bytes}

Const
    MaxNumberDataBlocks = 1000;
    MaxNumberFreeBlocks = 500;
Type
    word = integer;         {optionally remove for TP4}
    dataarray = array [1..$7FFF] of dword;
    Adr = ^dataarray;
    DIndex = 0..MaxNumberDataBlocks;
    FIndex = 0..MaxNumberFreeBlocks;

{Implementation section of a TP4.0 Unit}
Type
    DataBlock = record
                    DMemSeg : word;
                    DiskAddr: word
                end;
    FreeBlock = record
                    FMemSeg  : word;
                    DataIndex: dindex
                end;
    Data = array [DIndex] of DataBlock;
    Free = array [FIndex] of FreeBlock;
Var
    DataFile : file;
    DBuf : Data;
    FBuf : Free;
    NextPurgePointer : findex;
    NumberDataBlocks : dindex;
    NumberFreeBlocks : findex;

{Disk related procedures -}
Procedure InitReadWrite;
Var
    I : word;
Begin
    Assign (DataFile, 'data.tmp');
    ReWrite (DataFile);
    for  I := 1 to NumberDataBlocks do
        BlockWrite (DataFile, I, 1);
End;
Procedure ReadBlock (DataIndex : dindex);
Var
    temp : adr;
Begin
{$IFDEF DEBUG} Write (DataIndex:3, 'R '); {$ENDIF}
    with DBuf [DataIndex] do
    begin
        Seek (DataFile, DiskAddr);
        temp := Ptr (DMemSeg, $0);
        BlockRead (DataFile, temp^, 1)
    end
End;
Procedure WriteBlock (DataIndex : dindex);
Var
    temp : adr;
```

. listing continues

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```
Begin
{$IFDEF DEBUG} Write (Dataindex:3, 'W '); {$ENDIF}
    with DBuf [DataIndex] do
    begin
        Seek (DataFile, DiskAddr);
        temp := Ptr (DMemSeg, $0);
        BlockWrite (DataFile, temp^, 1)
    end
End;
Procedure CloseReadWrite;
Begin
    Close (DataFile)
End;

{Code central to VMM-}
Function InitData (Size, DNum, FNum : word) : boolean;
Var
    DataI : dindex;
    FreeI : findex;
    TempA : ^word;
Begin
    NumberDataBlocks := dindex (DNum);
    NumberFreeBlocks := findex (FNum);
    NextPurgePointer := findex (1);

    if (NumberDataBlocks > MaxNumberDataBlocks) or
       (NumberFreeBlocks > MaxNumberFreeBlocks) then
        InitData := False
    else
    begin
        InitReadWrite;
        for DataI := 1 to NumberDataBlocks do
        begin
            DBuf [DataI].DMemSeg := 0;
            DBuf [DataI].DiskAddr:= DataI - 1
        end;

        for FreeI := 1 to NumberFreeBlocks do
        begin
            GetMem (TempA, Size);
            FBuf [FreeI].FMemSeg   := Seg(TempA^);
            FBuf [FreeI].DataIndex := 0
        end;
        InitData := True
    end
End;

{Find next unused free block-return 0 if none found}
Function FindFree : findex;
Var
    I : findex;
Begin
    FindFree := 0;
    for I := 1 to NumberFreeBlocks do
        if FBuf [I].DataIndex = 0 then
        begin
            FindFree := I;
            exit
        end
End;

{Allocate particular Free block to particular Data block}
Procedure Alloc (DataI : dindex; FreeI : findex);
Begin
    with DBuf [DataI], FBuf [FreeI] do
    begin
        DMemSeg := FMemSeg;
        DataIndex := DataI
    end;
    ReadBlock (DataI)
End;

{Unallocate a Free block}
Procedure Unalloc (FreeI : findex);
Var
    DataI : dindex;
Begin
    with FBuf [FreeI] do
    begin
        DataI := DataIndex;
        WriteBlock (DataI);
        with DBuf [DataI] do
        begin
            DataIndex := 0;
            DMemSeg := 0
```

```
        end
    end
End;
Function Pdata (DataI : dindex) : adr;
Var
    Sgmnt : word;
    FreeI : findex;
Begin
    if (DataI = 0) or (DataI > NumberDataBlocks) then halt;
    Sgmnt := DBuf [DataI].DMemSeg;{get the memory pointer}
    if Sgmnt = 0 then              {if not in memory.}
    begin
        FreeI := FindFree;         {.get a free block.}
        if FreeI = 0 then          {.(no free blocks.}
        begin
                    {$IFDEF SHOWMISS} Write ('*');{$ENDIF}
            Unalloc (NextPurgePointer); {.make one).}
            FreeI := NextPurgePointer;
            NextPurgePointer := NextPurgePointer + 1;
            if NextPurgePointer > NumberFreeBlocks then
               NextPurgePointer := 1
        end;
        Alloc (DataI, FreeI);      {.and put in data}
        Sgmnt := DBuf [DataI].DMemSeg
   end;
   Pdata := Ptr (Sgmnt, $0)        {convert to addr}
End;

{Purge all data blocks out to disk}
Procedure Purge;
Var
    FreeI : findex;
Begin
    NextPurgePointer := 1;
    for FreeI := 1 to NumberFreeBlocks do
        if FBuf [FreeI].DataIndex <> 0 then
            UnAlloc (FreeI)
End;

{Close the VMM before terminating program}
Procedure CloseData;
Begin
    Purge;
    CloseReadWrite
End;

{test code - remove for a TP4 Unit}
{test VMM by allocating 1000 * 128 byte data blocks}
Const
    recsize =    128;
    noelems =     64;        {= recsize / dsize}
    memblocks =  100;        {# memory blocks to alloc}
    datblocks = 1000;        {# actual data blocks}
Var
    I,J : integer;
Begin
    if InitData (recsize, datblocks, memblocks) then
    begin
        {initialize the data blocks to known values}
        WriteLn; WriteLn ('initialize data blocks');
        for I := 1 to datblocks do
            for J := 1 to noelems do
                pdata (I)^[J] := I;

        {now access them randomly to prove we can}
        WriteLn; WriteLn ('access data');
        Randomize;
        for I := 1 to 2*memblocks do
        begin
            J := Random (2*memblocks) + 1;
            writeln (I:3, ') block ', J:3,' contains ',
                     pdata(J)^[1]:3, '  (',
                     pdata(J)^[2]:3,    ')');
            pdata(J)^[2] := I
        end;

        {finally purge remaining buffers to disk}
        WriteLn; WriteLn ('purge cached data');
        CloseData
    end
End.
```


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Continued from page 17...

3. Finally, notice that the example program uses a block size of 128 bytes corresponding to the default block size of Turbo Pascal. Under 3.0, the VMM must be modified slightly for different block sizes to calculate the proper disk block to use when calling *BlockRead* and *BlockWrite*. Because of this, the user data must be forced to some multiple of 128 bytes in length. Under 4.0, this problem is handled quite simply by adding another argument to the call to *ReWrite* indicating the proper block size for all subsequent file accesses.

The VMM program is written for 4.0, but can be executed under 3.0 by making a few simple modifications.

The VMM shown has been designed for maximum compatibility with Turbo 3.0. A "full 4.0" version of the VMM unit is available from CompuServe (as well as all of the software which appears in Turbo Pascal Corner). The version printed here is somewhat easier to use by allocating RAM blocks off of the heap up to the size of user data or until the heap is exhausted.

Hopefully, one or the other of these VMMs will find use among "Turbo Pascal Corner" readers who have more data than RAM to store it. □

Stephen R. Davis is a technical editor for Micro/Systems, *and a programmer for a defense contractor in Greenville, Texas.*

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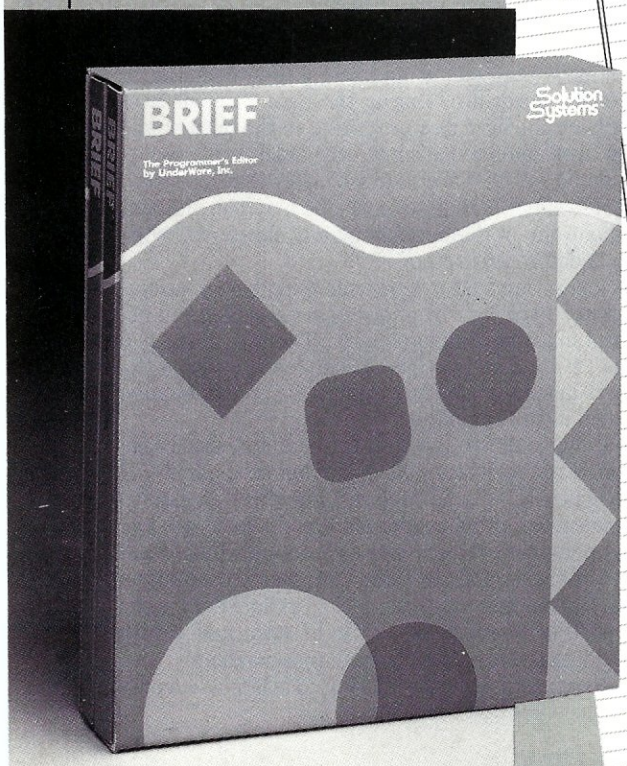

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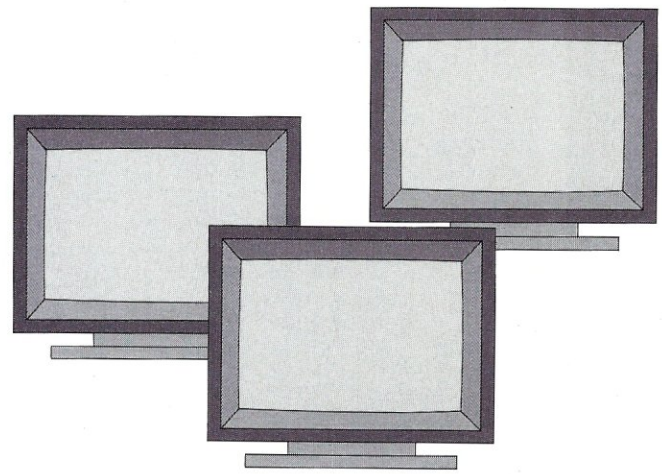
Making DOS Multiuser

by Stephen Randy Davis and Michael Hurwicz



New techniques make it possible for DOS applications to work in harmony with UNIX environments.

The first computer operating systems were single tasking in nature, capable of executing only one program at a time. The programmer stepped up with his stack of cards or paper tape, ran his single program, and retrieved his output from the line printer. During the time that program ran, the machine's entire resources were dedicated to the sole use of that program.

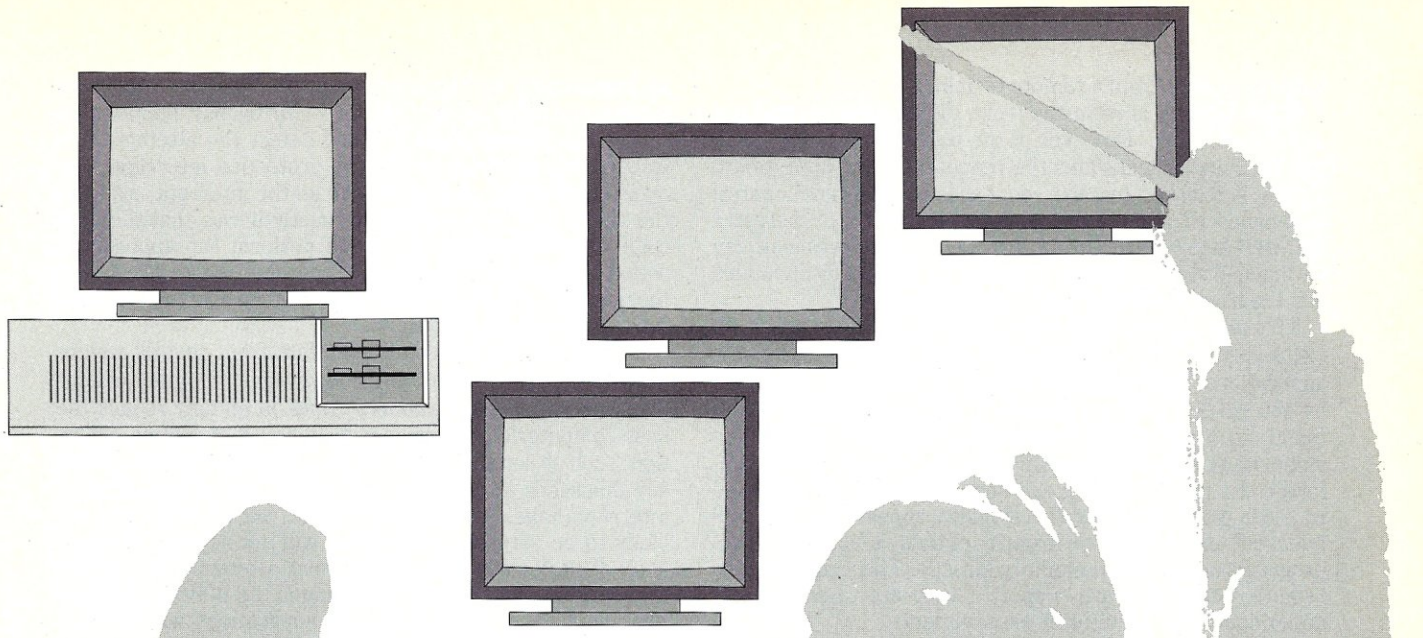
Mini and mainframe operating systems have not worked that way for some time. Multitasking operating systems that process more than one program at a time make much better use of the hardware. During the time that one program is accessing the hard disk or writing to the printer, the CPU can slip over and service some other task vying for its attention. Computer CPUs are so much faster than peripherals that the net effect is that several jobs may run simultaneously without any of them incurring any slowdown when compared to a dedicated system.

Multiuser operating systems provide even better utilization of computer hardware by allowing several users to access the same machine simultaneously. The operating system juggles CPU time and peripheral demands between the different users in such a way that each user appears to have solitary control of the computer.

Unfortunately, DOS was written for a simple hardware configuration. With its dual, single-sided floppies and 64K of RAM, the original PC was not deemed powerful enough to support a multitasking operating system. In addition, the cost of such personal systems was low enough that users were not too concerned, even if the CPU was not 100 percent utilized. But as time passes and PCs become ever more powerful, sporting upwards to 1 MB of RAM and 4 MIP processors, administrators are becoming increasingly concerned that computer hardware is going to waste when only one user can access it at a time.

DOS Under UNIX

Still, there is a lot of great DOS-based software already in existence, much of it already bought and paid for. Not too many sites are willing to scrap DOS compatibility for conven-



tional multiuser environments, such as UNIX. Over the years, many companies have attempted to address this need by adding multitasking capabilities to DOS with increasing success.

While not truly multitasking, "PopUp" programs provide many ease-of-use features. Shell programs, such as DESQview (see *Micro/Systems*, February 1988), Windows (see *Micro/Systems Journal*, January/February through November/December 1987), and Double-DOS retrofit limited multitasking. Microsoft's new operating system, OS/2, incorporates true multitasking of OS/2 applications, but it can still only execute one DOS program at a time. None of these approaches have seriously attempted to deliver multiuser DOS.

This situation is changing, however. The 80386 microprocessor's Virtual 86 mode can emulate several 8086's, each running with its own protected environment. Concurrent DOS from Digital Research and PC-MOS/386 from Software Link (see *Micro/Systems Journal*, November/December 1987 for reviews of these products) are multiuser/multitasking operating systems that run standard, well-behaved DOS applications. And, VP/ix from Interactive Systems and DOS Merge 386 from Locus Computing are shell programs that enable DOS applications to run under the UNIX multiuser/multitasking operating system.

With these systems, different DOS applications are simultaneously executed, each within its own virtual 8086. On UNIX systems, the shell program translates the UNIX services to the DOS services the application expects. The 80386's Virtual 86 mode keeps the inherently hostile DOS applications from interfering with one another. Each program "sees" its own 640K PC with a normal video display, ports, keyboards, and the like.

These types of systems have been very successful at bringing single-user multitasking to DOS applications. Unfortunately, this solution is not quite sufficient to allow most DOS applications to run successfully in a multiuser environment. The principal obstacle to smoothly incorporating these programs is the video display. Unlike many of its CP/M-based predecessors, the PC eschewed the lowly serial terminal, preferring instead the video display with its directly accessible display memory. Video adapters are more easily manipulated and give a more lively appearance. Unfortunately, they are essentially dedicated in nature and adapt poorly to multiuser environments. Any system that purports to offer multiuser DOS must answer the problem of display output.

There are three basic approaches to this problem: the all-software approach, the mixed hardware and software solution, and the all-hardware solution.

The All-Software Approach

Realizing that video hardware was likely to evolve and that it is the job of the operating system to insulate user programs from these changes, the PC was designed with basic support for all of the on-board hardware built into the Basic Input/Output System (BIOS). The BIOS contains a suite of low-level support routines that allow user programs to control all of the PC's hardware, including the video display. (Higher level support is provided by the PC-DOS operating system itself.) These BIOS routines are contained in ROM on the PC's motherboard.

Rather than hard code the entry points to these BIOS routines, the PC designers thankfully assigned an interrupt number to each access routine. At power-on initialization, the BIOS routine addresses are stored into the appropriate interrupt vectors. To access the video support routine, user code loads up the CPU's registers with their proper values, then executes a software interrupt 10 hex instruction (see Figure 1a).

True to the original plan, programs that access the video display via calls to the BIOS (and PC-DOS) can easily be adapted to a multiuser environment. During the boot-up process, the operating system need only replace the video interrupt vector with the address of its own routine. Whenever a DOS application performs an interrupt 10 to effect output, control is passed to the sophisticated multiuser video handler rather than to the original equipment BIOS routine. This handler checks to see whether the application performing the request is being executed from the main

video display or from a remote terminal.

If the request is from the video display, it is carried out exactly as before. However, if the request is from a terminal, the handler translates the request into the appropriate escape sequences (escape sequences are terminal control commands that generally begin with the ASCII character ESCAPE) (see Figure 1b). In this way, remote terminals can be induced to emulate most of the video display functions and the user sees what the program intended.

This plan is relatively easy to implement and requires no extra hardware. Unfortunately, it does not work for many applications. The problem is that the video support provided by the BIOS is very rudimentary. Applications developers found out long ago that programs could easily manipulate video RAM themselves with startling results. Users preferred the rapid scrolling and snappy appearance provided by such programs over the sluggish appearance of "well behaved" programs. The majority of today's "popular" DOS programs access video memory directly. These applications require some hardware support if they are to be brought under control in a multiuser environment.

Combined Hardware and Software Solution

In the so-called Real Mode, the 80286 and 80286 microprocessors do their best to emulate a standard 8086 or 8088. In Real Mode, they offer little advantage over their weaker siblings other than speed. This is the mode with which we, as users, are most familiar, since this is the mode in which DOS operates. In Protected Mode, the 80286 and 80386 microprocessors come equipped with a powerful set of structures for controlling access to memory. In particular, regions of memory can be marked as read- or write-protected. This feature can be used to address our screen-access problem.

The operating system knows that any program that accesses video memory is going to do so with segment descriptor 0xB000 for monochrome and 0xB800 for graphics displays. In Real Mode, this corresponds to the physical address of 0xB0000 and 0xB8000 of the video memory for these adapters.

A specially written operating system running on an 80286 in Protected Mode could emulate DOS. Such an operating system could mark segments 0xB000 and 0xB800 as inaccessible by the user program. Whenever the user program attempted to read or write display memory directly, the microprocessor would detect the attempted infraction and generate a memory protection interrupt. The operating system could then pick up the interrupt, examine the instruction to decide what exactly it was that the user code was attempting to do, and perform the appropriate action on the remote terminal. (Programs being executed by the user on the real video display would be allowed to access its memory without hindrance.)

Unfortunately, this solution suffers from several severe drawbacks. First, generating and servicing an interrupt for every access of video memory could potentially reduce the host computer's performance to a crawl. A simple operation, such as scrolling the screen up one line, requires literally thousands of reads and writes, and servicing that many interrupts takes a great deal of time. Such a scheme is not likely to be very popular—users will not accept the lower level of performance. Besides, most programs written for DOS assume that they are operating in the 8086-compatible Real Mode; the majority of such applications will not perform properly in Protected Mode.

Rather than generate a memory-protection interrupt, a multiuser DOS might simply remap the video segment to some other physical location in memory. Each user would be provided with an area of memory that becomes his "virtual display memory." Since each user's programs have full read and write privileges to this memory, they could gleefully read and write from this virtual display unimpeded, and no interrupts would be generated to bog down system performance (see Figure 2).

In such a system, getting each user's virtual display memory out to his real terminal becomes a problem. Typically, a background "demon" task must constantly search these video memories. Every time this task detects a change in one of these display memories, it simply ships out the new information to the corresponding remote terminal for display. This system is workable. (In fact, a very similar approach is used by such remote control programs such as Carbon Copy.) Unfortunately, it still does not address the serious problem of executing Real Mode applications under Protected Mode.

The situation with the 80386 is much better. Even in the

Figure 1a. User programs typically perform display output by invoking interrupt 0x10 to access the BIOS video support.

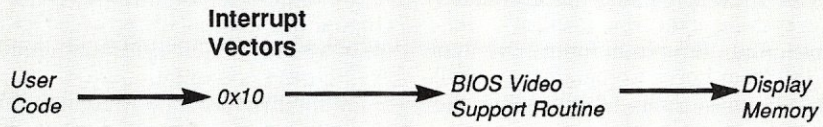
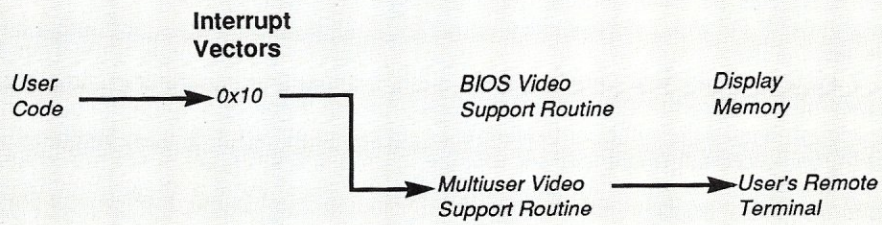


Figure 1b. The output of such programs can easily be redirected to remote terminals in a multiuser environment.



Virtual 86 mode, page mapping allows the 80386 to remap logical memory to a different physical location without resorting to special segmentation tricks. In such a multiuser environment, the UNIX-based operating system runs each DOS application in its own Virtual 86 environment, with its own video memory. The demon task works as a separate process to keep the actual terminals up to date.

Two products using this half-software/half-hardware approach have been introduced: XSight from Locus Computing and 386/ix MultiView from JSB Computer Systems, Ltd. XSight is designed to work on a 386 host and is compatible with Locus' "DOS under UNIX" Merge386 product. XSight is compatible with the emerging UNIX XWindows standard. The single-user "terminals" connected to the host must be dedicated PCs in their own right, each executing PC XSight. Connection between the host 386 and "terminal" PC may be inexpensive serial RS-232 cabling or high-bandwidth LAN interconnections for improved performance. When using a LAN, each PC may be connected to more than one host.

Requiring a dedicated PC for each user may seem like a strange requirement, but consider that the cost of PC clones without hard disks is roughly the same as that of simple ANSI standard terminals. By providing more intelligence at the peripheral, Locus claims to be able to relieve the host of much of the windowing workload.

A preliminary version of this system was on display at UniForum 88, the UNIX exhibition held in Dallas. Performance using an AT as a terminal communicating over a LAN was acceptable, but only marginally. What would have provided lightning-fast screen updates on a dedicated DOS system offered quick but jerky screen output when communicated to a remote "terminal." The jerkiness is due to the fact that no updates appear on the screen at all for long periods of time when the demon is not running. All at once, the demon gets a turn to execute and transmits the large block of updates that accumulated during its slumber. However, XSight does provide a complete and powerful windowing environment.

The 386/ix MultiView also ran on a 386-based host, this time using Interactive Systems' "DOS under UNIX" product, VP/ix. Unlike XSight, 386/ix MultiView requires only simple ANSI terminals at the user sites. This approach was chosen because it would to be more palatable for sites that may already be fully stocked with these terminals.

This system also was on display at UniForum 88. It was truly eerie to see WordStar running in a window with Lotus 1-2-3 in the background, all on a vintage DEC Model VT102 terminal! Although most of the jerkiness was gone, performance was worse than with XSight because it was limited to simple 19200-baud serial lines. Scrolling through a document from within the WordStar window took an unacceptably long time. In its non-windowing mode, 386/ix MultiView performance increased dramatically. (Due to the limitations of the terminals, JSB's product only supports applications that operate in text mode.)

Requiring a dedicated PC for each user may seem strange, but consider that the cost of PC clones without hard disks is the same as simple ANSI standard terminals.

All-Hardware Solution

Achieving multiuser video performance similar to that of a dedicated PC requires hardware support beyond that provided by the 80386 processor itself. So far, two approaches have been proposed. The first, being developed by Arnet, utilizes bank-switched video memory in what is known as a multivideo adapter.

The multivideo adapter actually consists of several video sections, each with its own memory and display circuitry, all located on the same card. Each video section is attached to its own monitor and assigned to a different user. Each dis-

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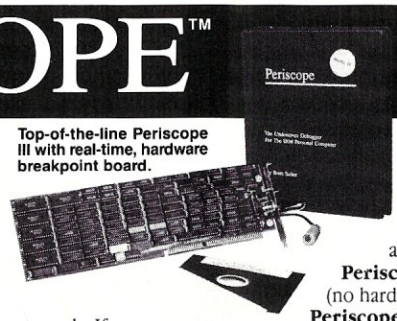

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Figure 2. A multiuser operating system may remap each user's video memory to a different block of physical memory. An independent demon task is responsible for outputting these virtual displays to real remote terminals.

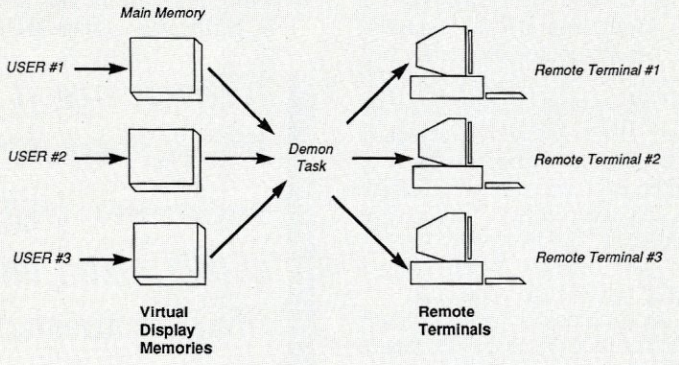


Figure 3. The MultiVideo Adaptor contains the circuitry for several independent video cards on the same board. The memory of these adapters is bank switched onto the host PC's bus so that only one of them is accessible at a time. Here User #3 is currently active so only his screen is accessible, however all users continue to see their monitors.

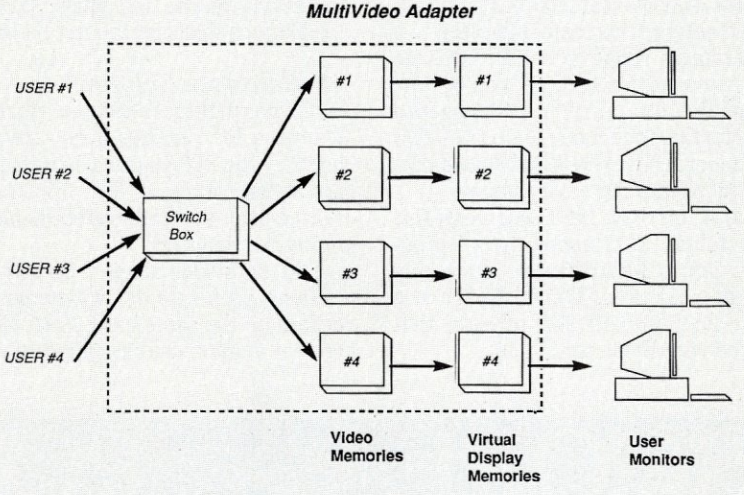
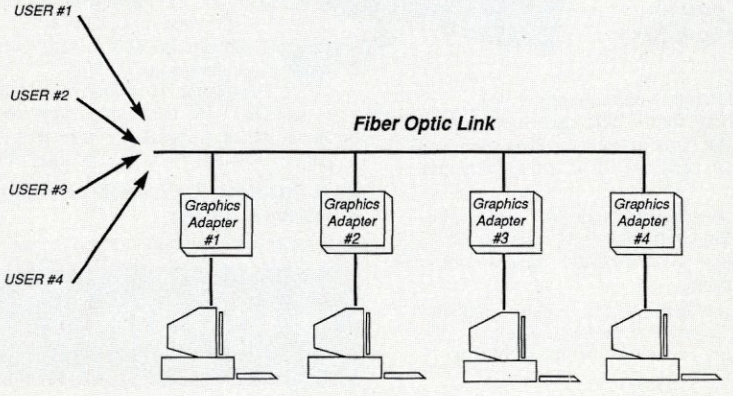


Figure 4. In the Cygna System bus information, including direct accesses of video memory, goes out to all video adapters via optical fiber. Only one of these is enabled to accept and respond to these signals, however.



play circuit constantly displays what is in its own memory. Only one of the display circuits is addressable from the host computer at a time (see Figure 3).

As the operating system alternately gives control to software being executed by the different users, it simply determines which display section is currently accessible by the host. For example, when Lotus 1-2-3 being executed by user A writes to video memory, it is writing to display section 1 which appears on user A's screen. By the time user B's Turbo C compiler attempts to write directly to the display, access has been switched to video section 2 which is attached to user B's display.

With the proper UNIX drivers and the support of "DOS under UNIX" packages such as Merge386 or VP/ix or other multiuser operating systems, such a system should provide very good performance. Since bank-switching the video sections is quite quick, multitasking performance should not be hindered, and without time-robbing demons output should be quick and smooth. The main problem with this scheme is

Achieving multiuser video performance similar to that of a dedicated PC requires hardware support beyond that provided by the 80386 processor.

that it requires video coaxial cable to be extended from the host to each user's monitor. This limits the physical size of such a system. The actual performance and pricing of this arrangement are not known, since the multivideo card has not yet been demonstrated.

An approach similar to this one was shown at last year's Comdex exposition and again at UniForum 88 by Sun River. In this solution, dubbed the Cygna System, a card is plugged into the host PC where the video adapter should be. This card takes electrical signals on the bus and converts them into serial pulses over a fiber optical bus. Specially made Cygna terminals connect to this fiber network. Each of these terminals contain their own fairly standard video adapter cards and monitors (see Figure 4).

When the current task attempts to read or write video memory, the signals go out to all of the Cygna video adapters. However, only one of the Cygna adapters, the one being used by the program currently running, is selected at a time. Each time the underlying operating system switches tasks, it disables the current adapter and enables the adapter of the new task. The Cygna host card includes a jumper that connects to the video adapter in the host computer, allowing them to work together. Cygna also provides a Cygna emulator card that can be plugged into a conventional AT or PC to allow the computer to emulate the operation of a Cygna terminal.

This solution runs very well. Scrolling is smooth and screen updates are lightning fast. Since Sun River offers terminals based on different standards, CGA, EGA, EGA+, and Hercules graphics can all be mixed on the same host. In addition, each terminal is equipped with its own keyboard

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and serial ports that are automatically switched with the video in a seamless fashion.

The only drawback to this solution is cost. Optical fiber and its connectors are not as inexpensive as simple twisted-wire pairs. In addition, the Cygna terminals themselves cost as much or more than a simple dedicated PC clone. If 80386 access is a requirement, however, this approach is still cheaper than providing multiple dedicated hosts.

Conclusion

Multitasking DOS is quickly becoming a reality using the special shells that allow DOS programs to execute as processes under UNIX using the Virtual 86 mode of the 80386 microprocessor. Unfortunately, there is more work to be done before multiple DOS users can simultaneously access the same 386 host. Here we have attempted to describe some of the problems and solutions currently being presented. Perhaps one of these solutions will allow you to make better use of your 80386-based hardware. □

Stephen Randy Davis, a technical editor for Micro/Systems, is a systems programmer based in Greenville, Texas. Michael Hurwicz is a freelance writer based in Nashville, Tennessee, who specializes in LANs and related computer technologies.

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Product Information

Merge386, XSight (not available at time of this writing)
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386/ix MultiView
JSB Computer Systems, Ltd.
Cheshire House, Castle St.
Macclesfield, Cheshire SK11 6AF
England
(44)0625-33618

MultiAdapter (not available at time of this writing)
Arnet Corporation
576 Woodycrest Ave.
Nashville, TN 37210
(615) 254-0646

Cygna System
SunRiver Corporation
102 Business Park Dr., Ste. I
Jackson, MS 39213
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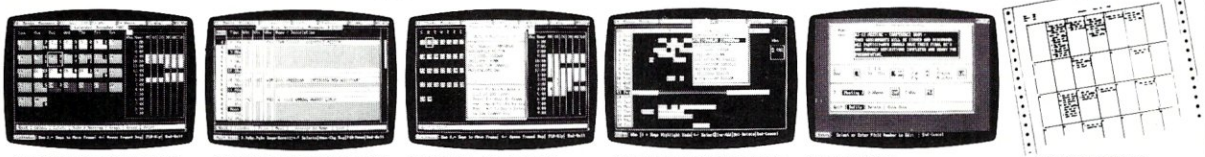

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Multiprocessing with MultiLink Advanced

Using statistically allocated memory partitions, this software link product adds multitasking, and multiuser capability to DOS.

Howard Vigorita

As microcomputers find their way into business settings, there is an increasing desire to share data entry and other computer-related tasks. MultiLink Advanced from The Software Link aims to satisfy these needs with relatively inexpensive serial ports and terminals.

MultiLink is an operating system modification package for an IBM-PC compatible that gives it both multitasking and multiuser capabilities. It is not, however, a complete, stand-alone operating system. All file handling is done through the existing DOS. In this regard, it more closely resembles Quarterdeck Systems' DESQview than Concurrent PC-DOS from Digital Research.

Memory Management

Although MultiLink Advanced runs on any IBM-PC compatible, it runs best on an 80286-based system compatible with an IBM PC/AT. For the purpose of this review, MultiLink was installed on a PC's LTD-AT, together with an AST Rampage and an AT Gizmo memory management unit. With this setup, MultiLink performs the neat trick of achieving a level of memory management normally associated with 80286 or 80386 protected-mode operation, while still running in 80286 real mode for the correct operation of DOS.

The AT Gizmo is a memory management card manufactured by Software Link for use with IBM PC/ATs and clones. Its use allows MultiLink to deal effectively with the increasingly common condition of IBM-PC software doing its screen output by writing directly to the memory mapped video's RAM buffer. With this unit installed, MultiLink can intercept and redirect any memory references, including those written to video RAM. When used in combination with the AT Gizmo, this makes MultiLink one of the only 286 real-mode systems that can tolerate concurrent processes writing directly to video RAM. By contrast, DESQview and Concurrent PC-DOS must suspend background processes to keep them from overwriting the real console.

Multiprocessing

MultiLink makes use of statically allocated memory partitions to achieve multiprocessing. Each partition has two memory regions: one mapped within the lower 640K area where DOS expects programs to run, and the other is mapped to the video buffer.

Virtual consoles are used to allow programs in multiple partitions to believe they each own the real console. With the aid of the memory management unit, each partition thinks it is writing to the memory location occupied by the video RAM when in actuality extended memory is being used. When a partition's virtual console is to be viewed, the virtual video buffer is copied to the real console's true video RAM buffer.

To load MultiLink, the MLINK program is run with command-line arguments that define the number of partitions and partition sizes, as well as the terminal types and baud rates. Partition memory allotment cannot be dynamically changed. To change the configuration of the system, it is necessary to reboot and execute the MLINK command with new parameters.

A separate copy of COMMAND.COM is run in each partition. By default, MultiLink switches partitions to the real console using the Alt key in combination with F10 for the lowest partition, or F1 through F8 for the first eight additional partitions. These partition-switching "hot keys" can be altered with a utility to avoid any conflicts with application programs that make use of the same keys.

It should be noted that MultiLink has no windowing features; no provision is made for simultaneously viewing portions of the various background partition consoles. When you hit the key for a particular partition, its virtual console will be swapped to the real console in its entirety. There is no simple facility to monitor a nonvisible partition's progress, other than to momentarily switch it to the console.

Multiuser Capability

The Multiuser capabilities of MultiLink are truly remarkable. It is the first software package featuring the ability to redirect video RAM accesses to a serial port. This ability is certainly within the grasp of protected-mode operating systems such

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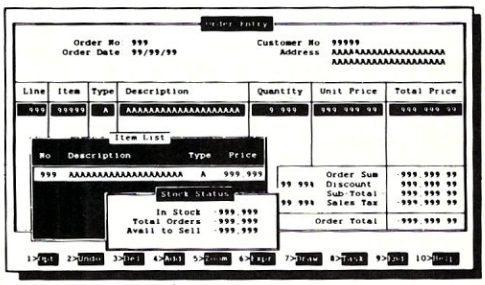

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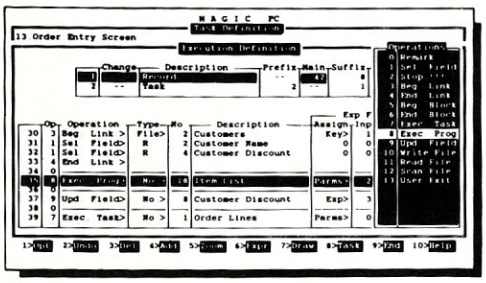

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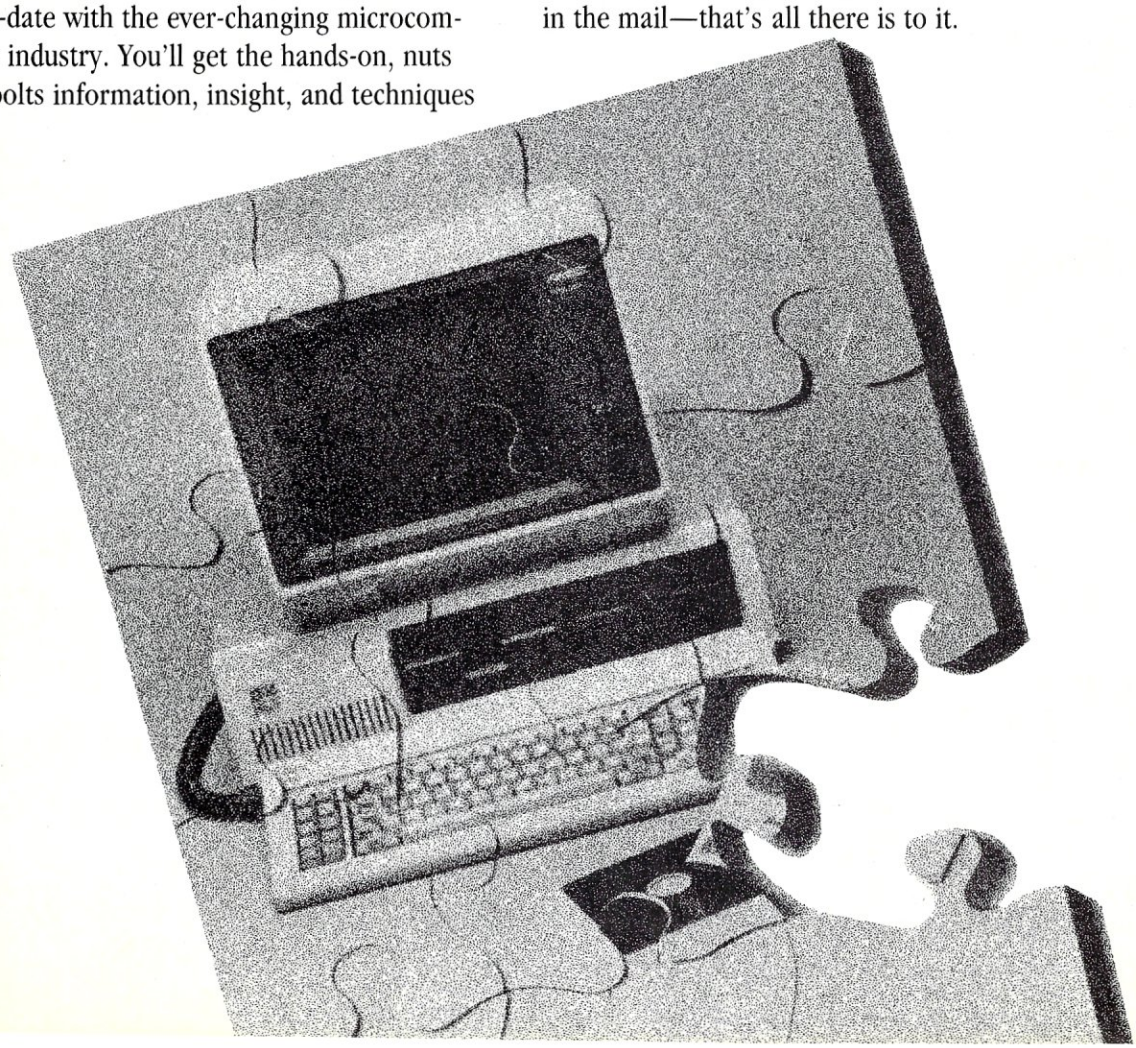

as Digital Research's Flex-OS and Concurrent 386, or MicroSoft's OS/2. MultiLink seems to be the first to deliver on this promise of advanced multiuser systems. You really can run standard versions of Lotus 1-2-3, Word Perfect, or dBASE III from a serial terminal.

MultiLink can handle up to 16 serial terminals. Software Link supplies expansion boards with either four or eight serial ports that operate at up to 115,200 baud. Although there are no terminals that operate that quickly, these ports can be used at that baud rate with Software Link's LANLink product to link multiple PCs with a moderately priced network. Software Link also has Wyse terminals available which are rated for 38,400 baud. These terminals are especially appropriate choices for running PC software, not only because of their speed but because of their PC-compatible keyboards and 25-line displays.

I tested MultiLink with a Hazeltine Esprit setup for an Esc lead-in character at 19,200 baud using XON/XOFF protocol.

MultiLink comes with a provision for 12 terminal configurations, of which the Hazeltine 1500 was a close choice but didn't work for my Esprit. This required the use of MultiLink's terminal setup utility. This utility is written as a filter, allowing answers to questions and escape sequences to be placed in a text file and fed in using input redirection. This eased the process of fine tuning and experimenting with my terminal installation.

MultiLink handled my 24-line display, standard keyboard terminal well, but it's awkward to say the least. Trying to emulate a PC with such a serial terminal is bound to be somewhat of a problem because of its incompatible display size and keyboard scheme. Escape sequences need to be typed in to cause MultiLink to display the top or bottom 24 lines of the normal 25-line PC display. Escape sequences are similarly used to emulate IBM-PC special function and Alt keys.

Multiuser coordination can be accomplished in MultiLink with either a semaphore system external to the operating system or through NetBIOS calls as described in the DOS 3.1 Technical Reference Manual. MultiLink emulates NetBIOS operation to provide file- and record-locking with software written for the IBM-PC Network or Token-ring Network.

For software written with only a single-user environment in mind, MultiLink provides a utility program that accesses semaphores. As a command-line parameter, you tell the utility which flag number you want to possess. Success or failure is returned via the MS-DOS error-level exit code. This facility is intended to be used with batch files. If a resource, such as a printer, directory, or file, is accessed exclusively through a batch file, the semaphore can be tested beforehand, and reset after running the command to access the resource. If the resource is not free, the batch file should jump around the access command and output an appropriate message. Sample batch files are provided as examples in the package.

Multiuser coordination can be accomplished with either a semaphore system or NetBIOS calls.

The real challenge in using the semaphore approach is deciding on a system and sticking to it. This consists of assigning resources, which may be files, directories, printers, etc., to an agreed semaphore and only accessing the resource when the semaphore is free.

Installation

A program is provided that reduces the installation process to answering a few questions about the hardware and partition sizes. The installation program then copies all the MultiLink files over to the hard disk and modifies or creates CONFIG.SYS and AUTOEXEC.BAT files. There are a number of variations to MultiLink installation that revolve around how to deal with direct video references.

From a software point of view, the least complicated installation is achieved by using the AT Gizmo memory management board together with an extended memory board (mapped above the 1 megabyte boundary of an 80286). The main thing is to have CONFIG.SYS load the GIZDRIVE.SYS device driver and for AUTOEXEC.BAT to run MLSIZE first. These steps are essential whenever the AT Gizmo is plugged into your system, regardless of whether or not MultiLink will be running.

Physical installation of the AT Gizmo is a little more involved. I had to rearrange other cards in my system, most notably the disk controller, in order to get the AT Gizmo closer to the 80286 CPU. The processor must be removed from the motherboard, installed on the memory management card, and a six-inch cable run from the card to the vacated socket. In this way, the AT Gizmo takes direct control of the CPU address lines, effectively rewiring them on command, to swap memory throughout the address space. A chip extraction tool is provided to facilitate CPU removal.

If the AT Gizmo is not used, there are two other possibilities that can be applied: (1) You can patch each application that you expect to run. Software Link provides a library of patches for various applications that are updated as new versions are released. (2) As a last resort, a resident utility is provided to monitor attempts to modify video memory by a switched-out process. However, this option invokes a substantial performance penalty.

The final installation step is to convert the demo version to a fully working version. The idea is to allow you to try MultiLink for a half hour before committing to purchasing it. I suppose this is useful to verify that it is compatible with your hardware. The converted file is not copy protected.

Usage

MultiLink is started up by running MLSLICE followed by MLINK. MLSLICE turns on time slicing to allow programs to continue running in background partitions while a different partition owns the real console.

The MLINK command is executed with parameters that determine the size and number of partitions to create. Since the syntax of the MLINK command can be rather detailed, it is advisable to place it in a batch file. If you put it in AUTOEXEC.BAT, booting from a floppy would permit running without MultiLink. Software Link recommends that FORMAT and DISKCOPY functions not be run under MultiLink. Oddly enough, Software Link also recommends removing the AT Gizmo before running DISKCOPY or, in the alternative, using the COPY command instead. I experienced no problems running DISKCOPY with the AT Gizmo plugged into my system.

Most of the software I tried performed well under MultiLink. This includes various versions of WordStar, dBASE, and Lotus 1-2-3, as well as a number of assemblers, interpreters, and compilers.

I had no problem using the MEX-PC modem program, but it is necessary to

... continued on page 68

Memory Management and EMS

by Howard Vigorita

As memory-hungry TSR utilities gain acceptance, the Expanded Memory Specification (EMS) gains importance in managing DOS memory calls.

Why would a single-tasking operating system like DOS ever need memory management? It wouldn't, if it really were single tasking.

What characteristics would DOS have if it were single tasking? It would make all its own memory allocations when the system was first loaded and not allow memory allocation while a running program was being interrupted.

From its inception, DOS has contained a terminate-and-stay-resident (TSR) system call. This allows a program to terminate and return to the operating system prompt without giving up the code and data space it occupies. The operating system then takes care not to use the TSR's space when it loads the next program. This facility was intended as a mechanism for loading system extensions, such as the basic I/O system (BIOS), without having to reassemble the operating system.

To use the original TSR system call, as provided by Version 1 of DOS, the DX register is loaded with the number of bytes to be reserved, and an *INT 27h* instruction is executed. A major drawback of this facility is that only 64K of memory can be reserved, and this can only be done at the time of the TSR call.

By Version 2 of DOS, this was remedied. A more flexible memory management system was introduced, and a new TSR call was provided as an *INT 21h* function. Application programs are now discouraged from using the old facility. To use the new TSR call, load the AH register with *31h*, load the DX register with the number of paragraphs to be reserved, and execute *INT 21h*. Paragraphs are groups of 16 bytes that start on an address divisible by 16. Since the 16-bit DX register specifies a paragraph count instead of a byte count, amounts in excess of 64K can be reserved. The amount of memory previously allocated to the TSR will then be modified to match the amount specified in the DX register, and control will be returned to the parent process, usually the COMMAND.COM program loader.

COMMAND.COM now allocates all memory that is available when it loads a program, unless the program file header specifies a lesser amount. Only an .EXE file has such a header. Once loaded, a program can use the new memory management calls to release previously allocated memory, or allocate new memory blocks. It is a good idea to reduce the program loader's allocation as soon as practical after a program loads. Otherwise, it will interfere with a resident TSR, such as a print spooler, that might need to allocate memory dynamically while your program is running.

With the TSR system call and the interrupt-driven design of DOS, you've got all the ingredients for multitasking. It

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was only a matter of time until programmers began writing TSR programs that started intercepting keyboard and timer interrupts to seize control from running programs. And when memory management was disengaged from the TSR call, the stage was set for application programs, TSR utilities, and the operating system itself to compete for—and quickly consume—memory up to the limits of the CPU. A way to break the 640K-DOS and one-megabyte Intel 8088 memory barriers was needed.

Early Memory Expansion Attempts

The initial exodus to DOS-based systems was fueled by the memory constraints of the 8-bit systems that dominated the business microcomputer market of the past. These systems used 16 address lines controlled by 16-bit offset registers to access memory and were thus limited to accessing 2^{16} or 64K of memory. In an attempt to stem the tide, banked switched memory was introduced. Banked switched memory contains special circuitry that can, on receipt of a command via an I/O port, electronically disconnect the address lines from a block of memory chips and reconnect them to a different block. In theory, this technique could be used to access an almost unlimited amount of memory.

When memory management was disengaged from the TSR call, the stage was set for application programs, TSR utilities, and the operating system itself to compete for memory.

Lack of a standard industry-wide scheme is the primary reason banked switched memory didn't save the day for 8-bit systems. A variety of hardware manufacturers adopted their own bank-switching protocols. The dominant 8-bit operating system vendor, Digital Research, provided only limited support. The BIOS of CP/M+ and M/PM-80 provided standardized bank-switching hooks, but only the operating system could use them. No provision was made to allow an application program to requisition additional memory. Usable program space could only approach the 64K limit, never exceed it.

In contrast, the Intel 8088 processor of the IBM PC has 20 address lines for access to 2^{20} bytes (1 megabyte) of memory. But having only 16-bit–wide registers, it takes two registers together to specify an address. In addition to a register that specifies an offset, a second kind of register, called a segment register, identifies the 64K block within which the offset registers operate. By changing the value in one of three segment registers, the 64K window seen by an offset register is changed. The advantage to application programs on the 8088 over 8-bit bank switching is that the procedure for moving the 64K window is clearly fixed in the instruction set of the processor.

Extended Memory

The CPU manufacturer, Intel, tried to extend memory limits from 1 MB to 16 MB with the 80286 processor. The 286 has 24 address lines but still has only 16-bit registers. To access the memory between 2 MB and 16 MB, known as Extended Memory, the 286 must go into protected mode, where segment registers are used to find 24-bit segment addresses in a memory structure called a descriptor table. Only a few programs, such as IBM's VDISK, use this memory because DOS has no extended memory allocation facilities, and the operating system, as well as most real mode programs, won't run correctly in protected mode.

Expanded Memory (LIMS or EMS)

As far back as 1985, Lotus Development Corporation and Intel announced their Expanded Memory Specification (EMS). This specification was designed to be compatible with existing software. When Microsoft joined in, it became known as the LIM specification (LIMS). This memory is often referred to as LIM memory, EMS memory, or expanded memory. EMS memory is bank-switched.

EMS calls for an Expanded Memory Manager (EMM), which is implemented as a device driver. The EMM can be opened using the device name EMMXXXX0, but normal manipulation is done with a software interrupt as an entry point. As when accessing the operating system, functions are called by putting a function number, with *40h* corresponding to function number 1, in the AH register and executing *INT 67h*.

EMS 3.x dictates that all bank switching into the CPU address space be confined to a 64K window, called a page frame, which must be located between the addresses of 768K and 960K. Various portions of the memory above 640K are dedicated to video RAM, disk controllers, and BIOS ROM, depending on the hardware configuration. Most EMS boards come with a utility that tests this area and reports unoccupied memory banks. Some EMS boards require that the address of the page frame be set on dip switches before it is inserted. Others require that it be specified as an argument in the CONFIG.SYS device statement.

Within the 64K page frame reside four subwindows referred to as pages. The standard page is 16K in size. These pages constitute four separate windows that look into the actual pages located on the EMS memory board. Different 16K pages of EMS memory can be bank-switched within the 64K window independently, or all four can be switched in sequence to look like a single window with pages 64K in size.

A number of different manufacturers, including Intel, supply EMS boards. The leading application software that takes advantage of EMS memory is the Lotus 1-2-3 spreadsheet program. As one of the movers behind EMS, Lotus uses it for data storage of spreadsheets that can span up to 2 MB. There are also a number of RAM disk and disk-caching utilities that use EMS.

Enhanced Expanded Memory (EEMS)

Not everyone was satisfied with the original EMS. In particular, Ashton-Tate, Quadram, and AST formulated an Enhanced Expanded Memory Specification, known as EEMS. The goal of EEMS was to make expanded memory as general purpose and as efficient as possible.

EEMS was defined with functions 1 to 15 identical to those of EMS (Table 1). This means that any program written for EMS will run under EEMS. What EEMS added were five new functions numbered 33–34, and 41–43. The major EMS rule which EEMS breaks is to allow bank switching to take place anywhere. Microsoft was understandably reluctant to support bank switching below 640K, in what is called conventional memory, out of fear that some part of the operating system might not be present when called. Special

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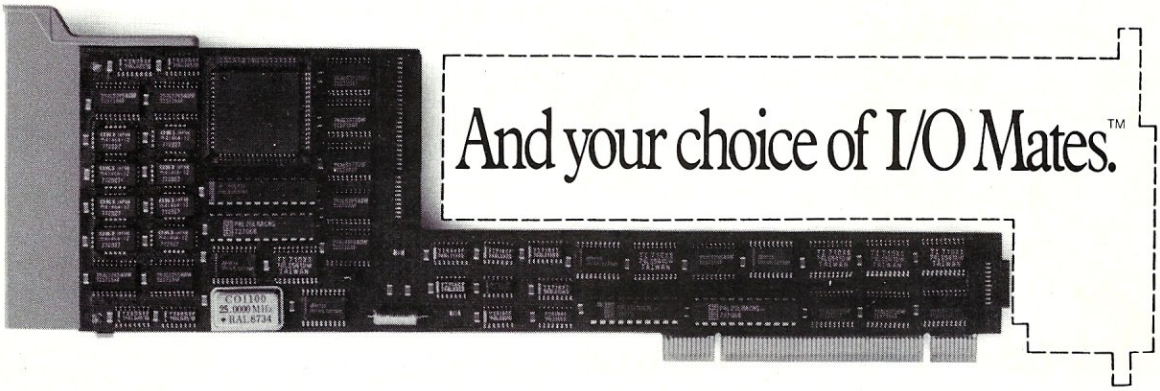

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care must be taken to ensure that interrupt service routines, device drivers, running code, and stack space are not bank-switched out at the wrong time.

AST and Quadram are the primary suppliers of EEMS hardware. Because of the lack of widespread cloning, prices for EEMS boards are a little higher than those of either the EMS or the Extended Memory varieties. The main third-party software packages that make special use of EEMS are the Concurrent XM-86 operating system from Digital Research and the DESQview environment package from Quarterdeck Systems. These packages permit concurrent execution of multiple programs, each as large as 610K in size, any of which can make EMS calls to access data.

EMS 4.0

With the coming of 32-bit processors and extended memory operating systems, a continued divergence of standards for breaking memory barriers on 16-bit real mode systems could set the stage for history to repeat itself. Recognizing this, in August 1987 the leading proponents of both EMS and EEMS announced EMS 4.0 which subsumes the functionality of both standards. Bank switching is back again, this time with a unified standard.

EMS 4.0 raises the maximum amount of expanded memory supported from 8 MB to 32 MB. The size of the page frame available to applications programs is also increased from 64K to 192K; twelve 16K pages may now fill the 768K to 960K region. And Microsoft has relented by allowing an additional 24 pages to occupy a second page frame in the region from 256K to 640K, with the caution that this region is intended for operating system and environment use only.

Although EMS 4.0 provides the functionality of EEMS, it does not duplicate the extra EEMS functions verbatim. Existing EEMS software will have to be modified in order to run under a standard EMS 4.0 driver, although there is no reason why AST couldn't support both EEMS and EMS 4.0 with one driver since there are no conflicting calls. EMS 4.0 provides new functions numbered 16–30 that can accomplish almost everything that EEMS does. The only exception is that EMS 4.0 recommends that EEMS function 34 for generic accelerator card support be implemented to coordinate with coprocessors that do their own buffering.

Function 17, *Map/Unmap Multiple Handle Pages* is the EMS 4.0 version of the EEMS cornerstone function 43, which achieves high performance by allowing multiple pages

Table 1. Expanded Memory Functions

FUNCTION	DESCRIPTION	LIM EMS 3.2	LIM EMS 4.0	AQA EEMS
1	Get status	✓	✓	✓
2	Get page frame address	✓	✓	✓
3	Get unallocated page count	✓	✓	✓
4	Allocate pages	✓	✓	✓
5	Map/unmap handle page	✓	✓	✓
6	Deallocate pages	✓	✓	✓
7	Get EMM version	✓	✓	✓
8	Save page map	✓	✓	✓
9	Restore page map	✓	✓	✓
12	Get handle count	✓	✓	✓
13	Get count assigned to handle	✓	✓	✓
14	Get count for all handles	✓	✓	✓
15	Get/set global page map	✓	✓	✓
16	Get/set partial map		✓	
17	Map/unmap multiple pages		✓	
18	Modify page count		✓	
19	Get/set volatile attribute		✓	

to be bank-switched with one call. Multitasking environments can utilize this function to rapidly switch from one task to another.

But EMS 4.0 goes further than just duplicating EEMS functionality. Besides getting input from AST, Borland was consulted on what it would like. As the marketer of Sidekick, the program that leads the TSR bandwagon and is largely responsible for consuming microcomputer memory in the first place, this is only fitting.

The information detailing which actual pages of EMS memory are mapped into which particular page frames in the CPU address space is called a mapping context. TSRs that alter page mapping strictly for data storage must explicitly save and restore the mapping context. This is to avoid interference with an interrupted application that might have also been using expanded memory. To ensure compatibility with EMS 3.x, functions 8 and 9, which save and restore mapping contexts, deal only with the old 64K window. To deal with the larger-sized context array associated with the higher capacities of EMS 4.0, the new functions 15 and 16 are provided. The mapping context is saved in an array, the size of which is determined by a subfunction of function 15. Function 16 lets you save a partial context for greater efficiency when you'll be using only a small number of pages.

For TSR utilities, pop-up programs, and even as an alternative to the use of disk overlays, functions 22 and 23 are added. These are intended to allow a program to put the bulk of its code or overlays into expanded memory and, when activated, allow its kernel (which must reside in conventional memory) to either jump to (function 22) or call (function 23) the previously loaded code not currently visible in any window. These functions automatically bank switch in the code and transfer control to it. In the case of the call (function 23), the EMS memory context at the time of the invocation is saved. When the code in the called subroutine, residing in EMS memory, issues a FAR RET instruction, the saved mapping context is restored before control is returned to the caller. Function 23 is especially handy for code in EMS memory that needs to call other code that has been loaded to different EMS memory pages. Note that although EMS 4.0 now ratifies code being executed in EMS memory, it cautions against putting a program's stack in expanded memory. These functions promise to reduce the conventional memory consumed by TSRs.

FUNCTION	DESCRIPTION	LIM EMS 3.2	LIM EMS 4.0	AQA EEMS
20	Get/set handle name		✓	
21	Get handle directory		✓	
22	Jump without saving context		✓	
23	Call then restore context		✓	
24	Copy/exchange memory region		✓	
25	Get physical mapping array		✓	
26	Get EMS hardware information		✓	
27	Allocate nonstandard-sized pages		✓	
28	Allocate DMA/alternate registers		✓	
29	Prepare for warm boot		✓	
30	Enable/disable OS/E functions		✓	
33	Get user physical mapping array			✓
34	Generic accelerator card support		✓	✓
41	Get entire physical mapping array			✓
42	Map page within entire page frame			✓
43	Get/set multiple pages			✓

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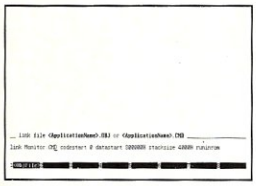

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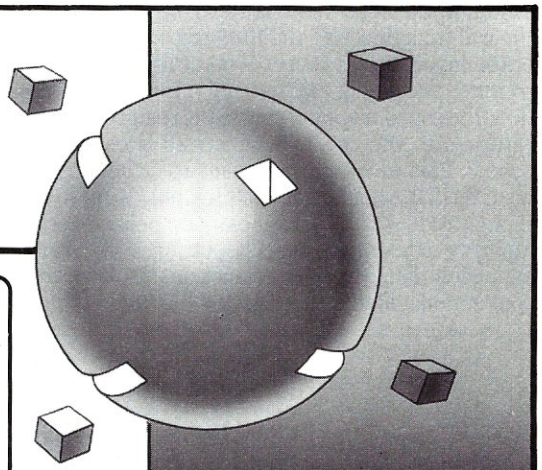

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Accessing Expanded Memory Pages

Expanded memory pages are accessed in a way that is similar to the way files are accessed. You have to first obtain a handle number by issuing an ALLOCATE PAGES call (function 4). You just put the number of 16K pages you want allocated into the BX register and the EMM returns a handle number in the DX register. Future page manipulation requires specifying the handle number. Function 18 has been added to increase or decrease the page allocation associated with a handle.

To facilitate interprocess communication and memory sharing, EMS 4.0 also introduces the concept of associating names with handles. Families of related TSRs that agree on a naming convention can share data or send messages to each other via expanded memory pages. Function 20 returns the handle number with which an agreed name is associated. A communication program running in the background, for instance, could send data into a named region of expanded memory that a spreadsheet program was monitoring. Function 21 provides further support with handle name searching and directory functions.

Special protected support functions are provided exclusively for the use of operating systems and environments. Packages like DOS and Concurrent PC-DOS are considered operating systems while packages that ride on top of DOS, such as DESQview and Microsoft Windows, are considered environments. Function 30 provides protection by returning a pseudo-randomly generated number to be used as an access key. The access key can be obtained only on the first invocation, unless it is given back to the EMM. With the access key, function 30 can be used to enable or disable functions 26 and 28. Function 26 returns low-level information about the EMS hardware, such as availability of alternate mapping register sets and special DMA hardware. Alternate register sets, if available, can obviate the need for saving context information in memory arrays, making for extremely rapid task switching and mapping context restoration. Special DMA channels on some boards are capable of transferring blocks of data between processor memory and the EMS board independently of the page mapping; a multiprocessing environment could do bank switching without waiting for DMA transfers to complete. Function 28 allows you to use these DMA and alternate register set capabilities.

Another unique feature is that EMS 4.0 RAM disks can be made to survive a warm boot. Function 19 assigns a nonvolatile attribute that tells the EMM to preserve the handle and allocation contents across a warm boot. However, not all systems will be able to support this feature. EMS boards plugged into systems that interrupt memory refresh during warm boot will be able to provide this capability only if the EMS board generates its own refresh signals.

Upgrading to EMS 4.0

One thing the current owners of EMS boards want to know is, can they upgrade to EMS 4.0 by just getting a new device driver. Absolutely—although a board that isn't physically able to bank switch more than a 64K window or place a window below 640K won't be able to do that with only a new driver. Nevertheless, upgrading to a new driver will at least provide the added functionality of named handles as well as jumps and calls into EMS.

Keep in mind that EMS drivers are hardware-specific. The new EMM will have to come from your EMS board manufacturer unless you have a clone of a popular product. Intel was the first to release a 4.0 driver, but the version I've seen doesn't have a provision for specifying page frames larger than 64K. AST boards have always had this capability, and a new driver should provide all EMS 4.0 capabilities.

The only other possibly limiting factor is the systems unit the EMS board is plugged into. An EMS card can only manipulate memory that is on the board. To locate a page frame below 640K, the EMS board rather than the systems unit should supply memory for this region. An ideal setup would be for the motherboard to supply the lowest 256K of memory, with the balance backfilled by the EMS board.

The next most asked question is how does EMS 4.0 fit in with the trend toward the 32-bit 80386 processor and the protected mode OS/2 operating system?

At first blush, you might think that since EMS 4.0 was designed to forestall the demise of 16-bit CPUs, all an 80386 could do with EMS 4.0 is make it run faster. Not so. EMS 4.0 seems to have been conceived with 80386 virtual 8086 (V86) mode in mind.

EMS, the 80386 and OS/2

V86 mode allows any 8086 operating system or application program to run on an 80386. In V86 mode, addresses are formed with segment and offset registers in the same way as they are on the 8086. Although this bypasses the descriptor translation that is normally performed in protected mode, page translation is still fully available. Page translation is a memory management feature that uses lookup tables to translate memory addresses before they are sent to the address bus. This allows a memory manager to rearrange the layout of memory throughout the entire extended memory address space by simply changing table entries. Such a capability is perfect for an EMM, and no additional hardware is needed. Indeed, this is exactly what the Compaq 386's CEMM.SYS does. A number of 386 AT clones are beginning to appear supplied with similar EMM device drivers (see "Memory Addressing on the 80386," *Micro/Systems Journal*, November/December 1987).

And how about EMS 4.0 and OS/2? This protected mode operating system was designed to run in the vaster expanses of extended memory. Running on an 80386 machine, OS/2 would have no need for EMS, other than to emulate it for DOS programs running in its DOS 3.x Compatibility Box. On an 80286, however, OS/2 could use an EMS board to make up for the paging hardware the 286 coprocessor lacks. But note that, without EMS hardware, full EMS emulation cannot be done on an 80286-based system. For example, data aliasing, a technique whereby data written to a single actual EMS page can be made to appear in more than one page frame simultaneously, cannot be achieved by emulation.

Summing Up

In sum, then, EMS 4.0 is an operating system extension that, counting subfunctions, adds 55 new memory management calls to DOS. Managing a memory region the same size as the maximum size of a DOS hard disk, it's almost an operating system in its own right. With its context-saving services, code execution capabilities, rapid task switching, interprocess communication, and operating system security functions, only the most sophisticated applications may require OS/2. In fact, Microsoft has promised that its Windows will fully support EMS 4.0 with a user interface (without advanced features such as the scheduler) identical to the OS/2 Windows/Presentation Manager.

The next logical step is for DOS to integrate its internal memory management functions with those of EMS. Wouldn't it be nice if, when you allocated memory using function *48h* of *INT 21h*, the operating system would take care of accessing the EMM and bank switch some memory into a suitable place for you to use it? □

Howard Vigorita, who serves as vice president of the New York Amateur Computer Club, is an attorney on the staff of the United States District Court in New York.

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Multitasking Under OS/2

by George Miller

Interprocess communications and dynamic linking are what give IBM's Operating System 2 its multitasking power.

OS/2 is a true multitasking operating system incorporating a number of different process-abstraction levels and interprocess-communication techniques. OS/2's kernel functions are kept to a minimum, because new functions can be added using the dynamic-link facility built into the OS/2 kernel. The implications of the dynamic link facility will be covered in more detail later.

The enhanced version of OS/2 (Version 1.1) will incorporate a graphics interface called the Presentation Manager. The Presentation Manager will provide additional synchronization facilities for use with the graphics-based window support system. These functions will not be addressed here since they are not available in the current version of OS/2 (Version 1.0).

Multitasking Model

A typical OS/2 environment is illustrated in Figure 1. The OS/2 process model has a number of different abstraction levels including "sessions," "processes," and "threads" (see Table 1). A session is a way for OS/2 to identify a program that may have one or more simultaneous paths of execution. There may be multiple sessions between which a user can switch. In general, a session will have a logical screen associated with it through which the user interacts with that session. The OS/2 session manager is used to switch between the logical screens.

A process is an executing program and it is executed within a session. A process is a collection of resources, such as files, memory segments, etc.

A process also includes one or more threads. A thread is the actual executing part of a process. Threads can be created and suspended, and they may terminate. A process terminates after all of its threads terminate. The thread concept allows multitasking to occur within a process as well as among processes.

Threads are designed to be created quickly and to require minimal overhead. This contrasts with sessions and processes, which are much more complex and have overhead associated with their creation or termination.

The maximum number of threads cannot exceed 255 and is set when OS/2 is loaded. The thread limit is set in the CONFIG.SYS file and should be large enough to accommodate the number of simultaneous programs to be run by OS/2. The limit cannot be changed after OS/2 is loaded. The limit may alter the way programs are written, and threads cannot be created with impunity because of this limit. Even so, it is very practical to divide a program into as many as a dozen threads, if necessary.

OS/2 contains a round-robin, priority-based, real-time scheduler. Processes and individual threads can change their priority as well as their priority class. Real-time threads have the highest priority for the best response time. Normal threads have a lower priority, while threads that are idle and waiting for a signal can select an even lower class. OS/2 handles threads within the same priority level in a round-robin fashion to allow programs equal access to the computing resources.

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Threads within a process are assumed to be cooperative because they may access any resource that is part of the process, including program code, stacks, and data segments. It is possible for one thread to corrupt the execution stack of another thread accidentally. However, resources of a process are protected from another by OS/2. This prevents a thread in one process from corrupting OS/2 or another process when multiple programs or terminate-and-stay-resident (TSR) programs are loaded.

The protection mechanism is provided by the protected mode of the 80286 and 80386. The hardware protection mechanism provides four levels of security. The OS/2 kernel has the highest privilege level, is the most secure, and has access to all memory and I/O. Application programs have the lowest privilege level while device drivers occupy the middle level. The other privilege level is not used by OS/2. The protection mechanism also isolates programs at the same protection level. Special segment descriptors called "gates" are used to move from level to level. More information on this mechanism can be found in Intel's 80286 and 80386 technical reference manuals. In general, this is transparent to the OS/2 application programmer.

Because of this protection, all interprocess communication must use OS/2 supplied functions. Communication between threads within a single process can use these facilities as well as shared-process resources, such as files and memory.

Interprocess Communication

OS/2 provides a number of different interprocess communication methods using resources such as "signals," "semaphores," "critical sections," "pipes," "queues," and "shared memory" (see Table 1). These basic methods can be augmented with additional functions that can be made available to all programs via the dynamic-link capability. OS/2 uses 16-bit handles for most resource manipulation, including files, processes, threads and queues. Other resources use 32-bit selector/offset memory addresses, including semaphores and memory segments.

Signals and semaphores are similar items, but semaphores can be shared among threads and created as necessary, while signals are associated with a process and are limited in type and number. Unlike a semaphore, a thread cannot wait for a signal to be set. Instead, a routine can be assigned to a signal. The routine is called when the signal is set. It can start a task that is waiting by setting a semaphore using one of OS/2's interprocess communication methods. One standard signal is the "critical error handler." This signal mechanism essentially replaces the special interrupt handlers found in DOS.

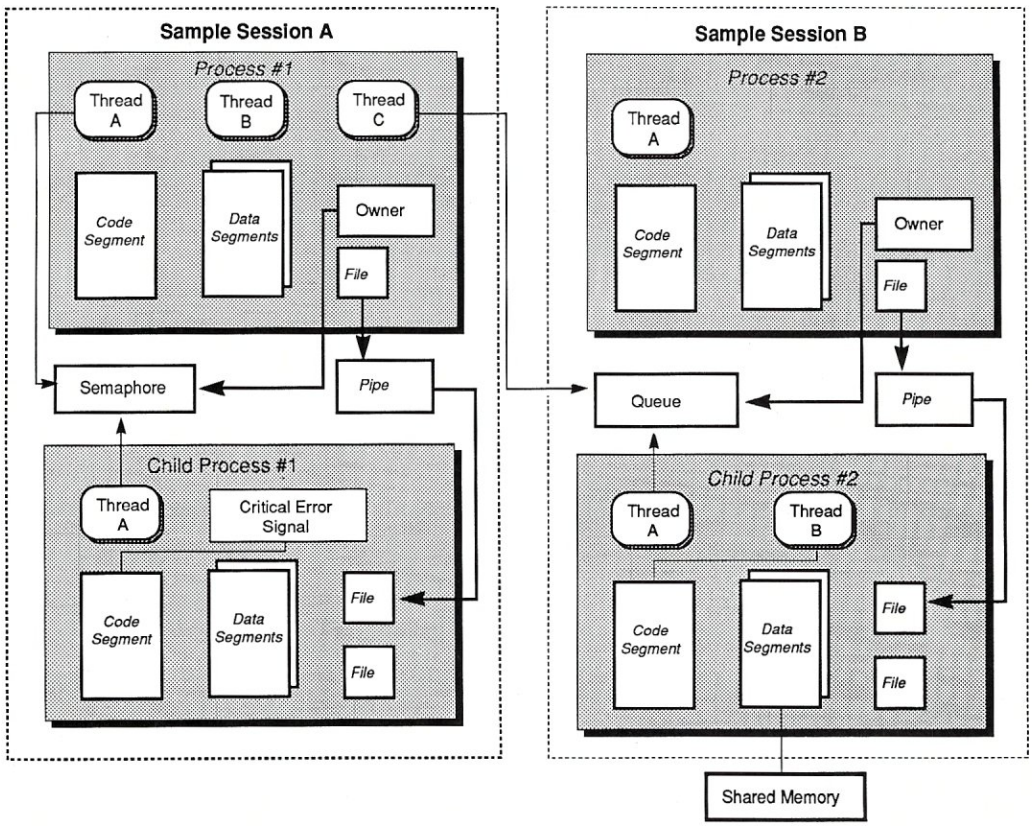

Figure 1. Sample OS/2 Environment

An OS/2 "session" is a group of one or more processes. A "process" has at least one active thread associated with it. Each thread has access to any resources owned by a process. All "resources" allocated by a thread become part of the process. "Pipes" can be shared with a child process, and "named pipes" (available under the LAN Manager extension) allow pipes to be between any process. "Queues" can be shared with other processes and provide a message-oriented communication channel that can have messages delivered in LIFO, FIFO, or priority order. "Semaphores" are also objects that can be shared with any thread. "Queues" can be augmented using semaphores, or a queue-style object can be built using semaphores and "shared-memory" segments. "Signals" are associated with a process, and each signal can have a routine associated with it. The "routine" can set a semaphore for which a thread can wait.

Semaphores are simple flags that can be set and reset. A thread can wait for one or more semaphores to change state. Semaphores are normally used to control access to other resources, such as files and shared memory. Semaphores are integrated into OS/2 and can be named and opened by name.

Alternatives to semaphores, in some cases within a process, are the DosEnterCritSec and DosExitCritSec functions. These functions prevent all other threads in a process from running except the calling thread. Such an approach is normally used to implement atomic operations within a process more efficiently than one could by using semaphores.

Exchanging information among processes can be done using pipes, queues, and shared memory. Pipes are special files that look like sequential files. Pipes in the basic version of OS/2 are unnamed and can only be shared among threads within the same process or among threads within child processes. The latter is accomplished using inherited files. Unfortunately, this mechanism is not as useful for arbitrary communication among processes. However, the LAN manager support in OS/2 does provide a feature called "named pipes." This allows any program to create a pipe and have any other program access it. Pipes work well for exchanging serial data but do not have the prioritizing mechanism of queues. Pipes use an internal buffer that allows data to be written into the pipe/file in small amounts. Pipes can also be used from any programming language that supports files.

Semaphores are normally used to control access to other resources, such as files and shared memory.

Queues, on the other hand, require a special set of functions not related to files. Queues can be named and shared among programs. Queue data is message oriented. A message is of variable size but must be placed into and removed from a queue as a single item. This is unlike a pipe, in which all information appears as a logical stream of bytes. Queues can order messages in LIFO (last in, first out), FIFO (first in, first out), and priority order. The information in messages is not defined. Large amounts of information can be exchanged among processes on the same computer using queues and selectors to shared-memory segments.

Shared-memory segments are a mechanism available through OS/2 that can be very useful and efficient. However, unlike DOS, a process cannot arbitrarily access the memory of another process without permission. Shared-memory segments in OS/2 are a way to give permission. Selectors for these segments can be exchanged among threads using pipes or queues. It is also possible to allocate a shared segment and give it a name, as with named pipes and queues. Access to shared-memory segments are normally controlled using semaphores and queues.

The basic interprocess communication methods provided by OS/2 are very powerful. They do not provide all the options. It is easy to come up with other useful methods, such as bidirectional and random-access pipes. Luckily these can be created using the basic OS/2 facilities.

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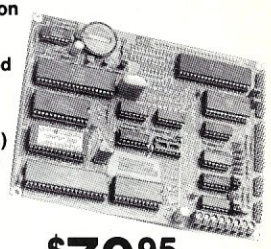

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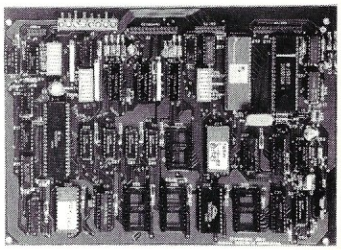

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Table 1. List of OS/2 Functions

Process Functions		
Dos CWait	Wait for child task termination	Process-related functions can be executed by any thread within the process. The DosExit function can selectively terminate a thread or the entire process and its children. The exit list is a set of functions to be executed when a process is set to terminate. These functions should be short cleanup routines.
DosExecPgm	Execute program	
DosExit	Exit program	
DosKillProcess	Kill process	
DosExitList	Modify termination list	
Thread Functions		
DosEnterCritSec	Enter critical section	Thread-specific functions allow control of a thread's own execution or of other threads within a process. One thread can suspend and resume another, but it cannot terminate it, which is unfortunate. Priority can be set at a process- and thread-level.
DosCreateThread	Create new thread	
DosGetPrty	Get process priority	
DosResumeThread	Continue thread execution	
DosSetPrty	Set process priority	
DosSuspendThread	Suspend thread execution	
DosExitCritSec	Exit critical section	
Session Functions		
DosSelectSession	Select foreground session	Session functions are simple and direct. They do not have to be used, but they allow a process to manage sessions. Sessions allow control of multiple processes, in the same sense that multiple threads are controlled as a single process. However, a session is a more nebulous entity, since the programs within it may not be related.
DosSetSession	Set session status	
DosStartSession	Start session	
DosStopSession	Stop session	
Signal Functions		
DosFlagProcess	Set signal	Signals are process resources that are related to DOS support interrupts such as critical error and control-break. Like DOS interrupts, signals can be turned on and off. Also, signals can only be processed when they are turned on. The DosFlagProcess function can be used on any process whose handle is available to a thread.
DosHoldSignal	Disable/enable signal	
DosSetSigHandler	Set signal handler	
Timer Functions		
DosSleep	Delay thread	General timer operations are available to any thread. Timers can be periodic or singular. Timers can be used to record a duration or cause an event to occur. Timers can be set by one thread and read by another thread within the same process.
DosTimerAsync	Start asynchronous timer	
DosTimerStart	Start periodic timer	
DosTimerStop	Stop timer	
Pipe Functions		
DosMakePipe	Create pipe	This single function is all there is for pipe support, since all other operations are standard file operations. DosMakePipe returns two file handles: one input file and one output file.
Queue Functions		
DosCloseQueue	Close queue	Queues are single-reader, multiple-writer interprocess-communication devices. The creator of a queue is able to read the queue. This includes multiple threads within the same process but not multiple processes.
DosCreateQueue	Create queue	
DosOpenQueue	Open queue	
DosPeekQueue	Peek queue	
DosQueryQueue	Query size of queue	
DosReadQueue	Read from queue	
DosWriteQueue	Write to queue	
Semaphore Functions		
DosCloseSem	Close system semaphore	Semaphores are simple entities that can be set and reset. They can be made available to threads outside the process that creates them. Semaphores can be used for mutual exclusion of resources. Semaphores cannot pass any information between the thread that sets it and a thread that clears it. As such, other mechanisms must be used to exchange information.
DosCreateSem	Create system semaphore	
DosMuxSemWait	Wait for one semaphore of a set to be cleared	
DosOpenSem	Open system semaphore	
DosSemClear	Clear semaphore	
DosSemRequest	Request semaphore	
DosSemSet	Set semaphore owned	
DosSemSetWait	Set semaphore and wait for next clear	
DosSemWait	Wait for semaphore to be cleared	

Adding New Facilities

The dynamic links are a facility found in OS/2 and in Windows. The facility allows a program to gain access to support functions directly instead of using the indirect methods provided by DOS. For example, DOS functions are normally accessed via interrupt 21 hex. An individual function is specified using a function code in a particular register. The interrupt routine uses this function code to jump to the corresponding support routine. This approach works because the location of interrupt 21 is known to all programs but the locations of the support routines are not.

Dynamic linking lets a program call the support routines directly, eliminating the overhead of the function code and the function selection code. The linker for OS/2 programs places the name of the function in the .EXE file, along with the references to it. The OS/2 loader uses this name and reference list to resolve the references using actual addresses. OS/2 system functions are provided to a program using dynamic links.

> *The specific features found in OS/2 are not unique to this operating system, but the combination of features is unique.*

Dynamic links can be provided by other programs and with dynamic-link libraries. Functions supplied this way are indistinguishable from functions supplied by OS/2. There is also no additional overhead. Simulating or masking functions in DOS normally means replacing the interrupt 21 handler and forwarding the appropriate function calls to it.

Although most links are resolved at program load time, it is possible for a program to make links after it is running and to use them as necessary.

Summary

OS/2 provides a very powerful multitasking process model, along with a set of intertask communication facilities and functions. The dynamic link feature of OS/2 allows extensions to be made in a transparent fashion. Additional pieces of OS/2 provide new features using this capability, including items such as named pipes via the OS/2 LAN Manager and window message facilities provided as part of the OS/2 Presentation Manager.

The features found in OS/2 are not unique to this operating system but the combination is unique. Overall, it is a well-thought-out design that is flexible and extensible. The kinds of programs that can be written under OS/2 will certainly be more interesting than those that can be created under DOS. This overview has tried to provide an idea of how these programs can work. □

George Miller is a network systems analyst based in New Jersey who has an interest in LANs, high-performance computers, and graphic environments.

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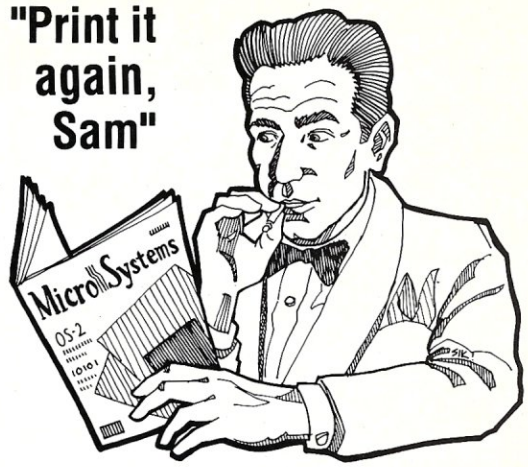

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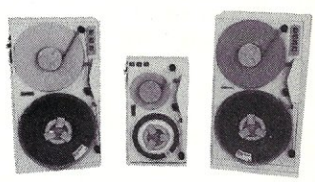

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THEOS 286-V Operating System

A multiuser, multitasking operating system that taps 80286 protected mode and breaks the 640K memory barrier.

by Walter Stagner

THEOS 286-V Version 2.2 is a multiuser, multitasking operating system that incorporates many new features including EGA support, BASIC language support of the 80287 math coprocessor, support for PC terminals, a hardware security device to discourage software piracy, and support for several foreign character sets. THEOS development and licensing is strictly controlled by THEOS Software Corporation; thus, application software developed under THEOS 286-V will run on any hardware that runs the operating system.

THEOS 286-V runs on most 80286/80386-based systems, including PCs from Compaq, IBM, ITT, NCR, Sperry, Televideo, Victor, and Wyse. It also runs on super-microcomputers from IBC, Third Coast Technologies, and Altos.

I evaluated THEOS on a Compaq DeskPro 386 with 2 MB of RAM, a 40 MB hard disk, and a Compaq color monitor with an EGA card. THEOS requires a minimum of 640K of RAM, one parallel port, and a hard disk. The operating-system files occupy approximately 1.75 MB of disk space.

THEOS 286-V supports three users on a standard IBM PC/AT. Up to 32 users and 16 spooled printers can be supported by increasing the system's memory beyond the minimum 640K and adding serial port cards and ASCII terminals. With EEMS (Enhanced Expanded Memory Specification) memory boards, THEOS 286-V can address up to 16 MB of memory, allowing many large programs to be in memory for quick access. The 80286/80386's memory management capabilities are utilized to prevent users from crashing a system or writing over another user's files and data.

Memory Management

Memory allocation for the operating system, applications, and data files is automatic and transparent to the user. During the boot process, THEOS reads the CMOS data ROM chip to determine the size of the system's memory and find out if a math coprocessor is installed.

THEOS uses the available memory, up to 16 MB, to store application programs or frequently used operating system commands, thus speeding their execution. These programs or commands may be loaded into memory automatically at boot time by using the SYSGEN command. To conserve memory, compiled BASIC and C programs and all operating system commands are "re-entrant." Whenever a program or operating system command is executed, THEOS searches the memory to determine if the program has been loaded. If it has been, the program can be shared among the users.

THEOS works with the 80286's internal memory management circuitry, sectioning the memory into segments. Passage from one segment to another is tightly controlled by assigning each segment one of four security levels, the highest security level being reserved for the operating system. THEOS uses the chip's privilege level feature to assign internal priorities. The operating system kernel has the highest privilege level, while applications have the lowest privilege level.

Installation

The installation procedures are provided for PCs and super-micros. In both cases, the THEOS-supplied security device is first installed in the primary parallel port. Without it, THEOS will partially boot, displaying the copyright notice and an error message instructing the user to "check connectors." This device has caused some controversy with users and programmers, but since it prevents unauthorized copying of operating system or application software, it has been generally accepted. The documentation explains how to install the device and what happens if it is not installed. A parallel printer can be plugged into the connector on the security device, if desired.

If DOS is already installed on the hard disk, the DOS partition must first be moved to the inner (higher numbered) cylinders before installing THEOS. This means that the DOS partition must be backed up and reinstalled. THEOS requires that disk cylinder zero not be assigned to any partition and that a minimum of 100 cylinders be allocated to THEOS. The DOS partition must begin after the THEOS partition.

Upon booting the system, THEOS displays an installation menu allowing the operator to select a new or upgraded installation. Next, the hard disk sizer program is executed. THEOS provides an extensive list of hard disk configurations from which to choose. Facilities also are provided on the menu to configure a hard disk not on the list (although you must know the number of heads and cylinders for the drive). THEOS can thus be configured easily for many PC compatibles. THEOS's automatic sector sparing routine, if selected, automatically maps out bad hard disk sectors (the procedure requires approximately one hour per 10 MB of disk space).

Near the end of the installation, I found it somewhat confusing when I was prompted to answer questions about buffers and what files are to be

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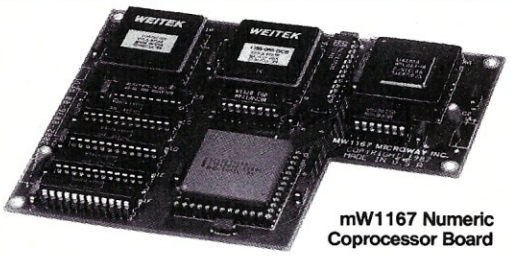

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The key to addressing more than 640 kbytes is the use of 32-bit integers to address arrays. NDP Fortran-386 generates 32-bit code which executes 3 to 8 times faster than the current generation of 16-bit compilers. There are three elements each of which contributes a factor of 2 to this speed increase: very efficient use of 80386 registers to store 32-bit entities, the use of inline 32-bit arithmetic instead of library calls, and a doubling in the effective utilization of the system data bus.

An example of the benefit of excellent code is a 32-bit matrix multiply. In this benchmark an NDP Fortran-386 program is run against the same program compiled with a 16-bit Fortran. Both programs were run on the same 80386 system. However, the 32-bit code ran 7.5 times faster than the 16-bit code, and 58.5 times faster than the 16-bit code executing on an IBM PC.

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permanently loaded. Some guidance on these subjects should have been provided in the installation instructions and would have saved me a phone call and some time.

All in all, it takes about 30 minutes to install THEOS on a PC. On non-DOS super-micros and PCs without a DOS partition, it takes less time to install THEOS since the DOS partition does not have to be relocated.

Documentation

The run-time version of THEOS (which does not include the full-screen editor or BASIC) is supplied with a loose-leaf binder, PC-style reference manual and a spiral-bound Quickstart booklet. The manual is organized into sections on fundamentals, procedures, commands, LINEEDIT, and the EXEC language. Not surprisingly, the command section is the most detailed.

The Quickstart booklet details installing THEOS, multi-port expansion boards, and streaming tape drives. I would have preferred a step-by-step tutorial detailing installation procedures from beginning to end. Even experienced computer users need guidance when working with an unfamiliar operating system.

The THEOS Multi-User Development kit is supplied in a loose-leaf binder inside a PC-style slipcase. The BASIC language documentation occupies the majority of the manual, while the Definitive C language (THEOS's version of C) and the text processor (Script and Edit) make up the balance. Much of the BASIC manual is devoted to examples of using BASIC commands, statements, and functions.

Getting Started

Considering the amount of detail in the documentation, it's surprising that a tutorial on how to get started has been omitted. Fortunately, THEOS provides on-line help. At the operating-system prompt one can enter HELP and THEOS displays a command summary and the function of each command. Specific help on any command, including the usage and command-line syntax, can be obtained by typing HELP and the THEOS command name.

Commands and Shells

Commands are entered via the Command String Interpreter (CSI), which accepts a string composed of commands and options. Over 50 commands are provided. A command may have one or more keywords that affect its operation associated with it. These keywords are called *command options.*

For example, the FILELIST command is used to display a disk directory on the default drive. The (PRT option is used with FILELIST to output the disk directory to the printer:

```
FILELIST (PRT
```

CSI also checks the command line for proper syntax, allows recall and editing of the last 16 command lines, and saves the command line in a CSI history file for subsequent recall.

LINEEDIT is a line editor included with the run-time version of THEOS. Although LINEEDIT is adequate and easy to learn, I highly recommend the full-screen editor called EDIT. EDIT creates and maintains files for use by system programs, such as the EXEC language, BASIC, and C compilers. EDIT is included with the SCRIPT text processor, allowing customized formatting and printing of EDITed files. Although EDIT and SCRIPT can be used for routine word processing tasks, I prefer to use a dedicated THEOS word processor, such as multiWRITE from Logic Extension Resources. MultiWRITE resembles MultiMate Advantage in cosmetics and function and includes an on-line spelling checker and thesaurus.

A three-level hierarchical system utilizes a main dictionary, libraries, and individual files.

THEOS 286-V provides a spooler that supports up to 16 printers. Spooler functions can be automated via the SYSGEN command or manipulated manually using the SPOOLER command.

THEOS contains the EXECutive Job Control Language, allowing programmers or experienced users to write EXECs that execute THEOS functions or that isolate novice users from the operating system via a series of menus. The EXEC language is used extensively by many VARs to automate housekeeping functions and reduce their software support time.

Programmers use the EXEC language to define batch and interactive procedures to coordinate a series of program modules that comprise a software package. Programmers may create an EXEC menu program synonymous with an account name. Any person logging onto that account will be limited to performing the predetermined set of tasks specified by the menu. By varying the menu's complexity, programmers can fit their application package to each client's level of expertise. The EXEC language, in my opinion, is one of THEOS's most important features.

THEOS File System

THEOS has removed the burden of file access and organization from the programmer by providing support for four data file types. *Sequential files* contain records that must be accessed in sequence or updated by appending records to the end of the file. *Direct files* are addressable by record number, permitting fast access. MultiWRITE utilizes direct files for its dictionary and thesaurus files. *Keyed files* are accessed by record key not maintained in any specific order. *Indexed* or *ISAM* (Indexed Sequential Access Method) files are accessed through a record index maintained in alpha-sorted order.

THEOS's three-level hierarchical file system utilizes a main directory, libraries, and individual files. The main directory and libraries are hashed files, so linear searches are not required. THEOS file descriptions consist of a file name and a file type, both of which can be up to eight characters in length. File descriptions are categorized as main directory entries. For convenience as well as speed, files can be organized into libraries. A library is a main directory entry with subcategory members. Libraries organize an account's files, enabling users to access files quickly and easily. Libraries are named in the following format:

```
filename.filetype.membername
```

For example, I might store this document as THEOS.FILES.THEOSREV. If THEOS.FILES is designated as the current library, only the membername THEOSREV need be entered to access the file. Libraries are routinely used to organize the system. Program files can be stored in one library, data files in another, and help or screen files in another. All THEOS commands are stored in a library. Unlike DOS partitioned data sets, in which each member must have the same record format and organization, a THEOS library can contain members that have any THEOS-supported file type.

File access time is also improved through the use of directory buffering. THEOS retains up to 64K of the file di-

rectory entries most recently used in memory. Since the directory buffer operates independently, it does not get swapped out of memory by unrelated processes. For software applications that open and close many files in a multiuser environment directory buffering reduces the number of disk reads, thus improving program performance.

Multiuser and Multitasking

THEOS is inherently multiuser and multitasking. Although multitasking can be invoked by placing a job (such as compiling a program) in the background, THEOS also uses multitasking internally as a means of system resource management. If a process requests a resource that is not available, or if it requests input from an unused terminal, THEOS finds another task to execute until those resources are available, thus allowing more efficient multiuser operation.

To effect multiuser operation, a memory partition must be allocated for each user and each associated ASCII terminal using the START command. To start a memory partition, THEOS needs to know the user number, the port used, and the terminal type. For example, to allocate a memory partition for user 2 using a Televideo 950 terminal on port 2, enter the command

```
START 2 (SIO2 C31 B9600
```

where START is the command, 2 is the user number, SIO2 is the physical port number, C31 is the THEOS class code driver for a Televideo 950 terminal, and B9600 is the terminal's baud rate. Class codes define the terminal type. All multiuser startup parameters can be automated at boot time by entering the data via the SYSGEN menu.

Loading A THEOS Kernel

THEOS provides two methods for adding users or for changing major operating-system parameters. The START command can be used to add a user, and the ATTACH command can be used to add peripherals, both without rebooting. The SYSGEN command provides an automatic menu system, allowing all multiuser operation parameters to be selected from a menu and stored for future boots. It also allows peripheral devices, such as printers, terminals, and disk drives, to be added.

Since THEOS, as supplied, is configured for only the main console, I would have appreciated more examples in the documentation to help me configure a larger capacity system.

Electronic Mail

THEOS provides the ability to communicate with other users on the system via the MSG (message) and MAILBOX commands. MSG sends messages to any terminal connected to the system. If a user is not logged on, the message is placed in the user's mailbox. If a user is already logged on, the message is displayed immediately. Users are informed of mail in their mailbox and must use the MAILBOX command to read their mail.

DOS Compatibility

THEOS and DOS partitions can be created on the hard disk, provided that THEOS is installed first. However, they cannot be run concurrently.

The GETFILE and PUTFILE commands allow the exchange of ASCII sequential files between THEOS and DOS. Access is permitted to either floppy or hard disk. GETFILE reads and translates a DOS file into THEOS format placing it in the THEOS partition or onto a THEOS-formatted floppy disk. GETFILE can use wild card characters as well as DOS path names. GETFILE can also display a DOS directory on the specified drive.

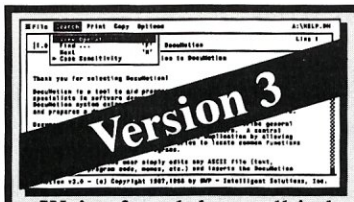
PUTFILE translates a THEOS file into DOS format and writes the file to the DOS hard disk partition or to a DOS-formatted floppy disk. It can also be used to clear the directory on a DOS floppy disk.

I was able to connect my PC/XT to my THEOS system using a modem cable port to port. Under DOS on the XT, I ran the ProComm communications program (set to emulate a Televideo 950 terminal) in the terminal-emulation mode and was able to access THEOS. Using ProComm's DOS gateway feature, I could temporarily suspend the THEOS session, exit to DOS, and run an application such as Lotus 1-2-3. Once ProComm is configured and the two systems are physically connected, this arrangement is quite convenient.

System Administration

Because of THEOS's on-line help and its easy-to-remember commands, you don't need to be an expert to maintain a system, although I recommend some training beyond the documentation. I think a section in the System Reference Manual on system maintenance would be a good idea.

Most THEOS systems are sold by systems houses or VARs who create EXEC menus to automate system operation, including the data backup procedures. If a user does end up at the sys-



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tem prompt, all the user need do is type the name of the EXEC to display the appropriate menu.

THEOS is generally forgiving of power outages. The system manager can use the DISK command with the (SHOW option to check the hard disk for damaged files. Damaged files are reported as a disk misallocation and can be repaired using the DISK command with the FIX option. But to be safe, I recommend replacing damaged files with backups.

A number of VARs with whom I have spoken tell me that most THEOS installations are self-maintaining, with some occasional user handholding.

Programming Languages

The standard application interfaces are the THEOS BASIC and C languages. THEOS BASIC comprises over 500 commands, statements, and functions. BASIC's interactive editor, interpreter, syntax checker, and on-line help enable a programmer to work efficiently. The two-pass compiler translates THEOS BASIC programs into object code, enabling them to execute faster.

The THEOS Definitive C language, compatible with the Kernighan and Ritchie C standard, provides program portability. THEOS's C function library covers all of routines that would normally be required in a sophisticated program. THEOS Definitive C includes an assembler, a linker, and a debugger. RM Cobol has also recently become available for THEOS.

Productivity Tools

Phase One Systems markets the Control Plus development system to supplement the THEOS operating system. In its most basic incarnation, Control Plus transforms THEOS into a database management tool using commands for screen building, data entry, and report writing. Programmers can also use it to generate screen displays and bug-free THEOS BASIC code.

Support

THEOS Software Corporation provides telephone support to anyone who has a signed license agreement on file. Support is free for the first 90 days. On several occasions, I had support questions that required written responses. The responses I received were both thorough and prompt.

THEOS Times, a semiannual magazine ($10 per year), is published by THEOS Software Corporation. It serves as a hardware- and software-buyer's guide and as a source for technical tips. Updates and enhancements are announced in the magazine and are available directly from THEOS or from THEOS dealers.

Summing Up

THEOS was designed as a multiuser, multitasking operating system. It exploits the protected-mode feature of the 80286/80386, and overcomes the 640K memory barrier of PC systems, addressing up to 16 MB. Although the documentation could be improved by adding thorough installation instructions, more details on the SYSGEN command, and a getting-started tutorial, once THEOS is installed a user can at least explore the basics of the system using the on-line help. Designed primarily for business applications, it provides the most friendly user interface I've seen in a microcomputer multiuser operating system environment. Its ease in use and minimal maintenance requirement, and the availability of its productivity tools for programmers, make THEOS 286-V a strong contender among multiuser microsystems. □

Walter Stagner is a systems consultant, author of several computer books, and a documentation writer. His interests include multiuser operating systems, application software evaluation, system installation, and training.

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The Pick Operating System

A practical operating system that provides greater power than DOS for entering, storing, and retrieving data.

by Walter Stagner

Dick Pick began developing the Pick system while employed as a programmer for TRW. He was intent on developing an easy-to-use, powerful database management system. In the late 1960s, Pick's application package ran on several mainframe computers. In the early 1970s, Pick transformed it into a stand-alone operating system with information management at its center. It has since been implemented on several mainframe and minicomputers sold under other names and recently ported to PC/XTs, PC/ATs, and compatibles.

The Pick® system provides an efficient environment for entering, storing, and retrieving data. It also transforms a PC/AT into a multiuser system with more power than a system using DOS and one of the popular database programs.

I evaluated Pick R83 Version 2.1 on a Sperry IT with a 44-MB hard disk, 512K of memory, two serial ports, and two parallel ports. Pick requires a minimum of 512K of RAM, and a hard disk with 2 MB of contiguous disk space.

Overview

The PC/AT version is available in three-, six-, and ten-user versions. The first user (line zero) is always the PC memory-mapped video monitor. Two, five, or nine serial ports are supported, depending upon the version. Each serial port can be used for a terminal, a serial printer, or a modem. Up to three parallel printers are supported, and slave printers may be connected to terminals having an auxiliary port.

Pick is an operating system designed within the framework of a database management system. For example, to list the disk files within a Pick system, you use the LISTFILES PROC, which executes a series of ACCESS commands (Figure 1).

Figure 1. Pick Terminology

Pick System	Other Operating Systems
Item	Record
Item-id	Key
Attribute	Field
Frame	Disk sector
Verb	Command
Line	Serial communication line used to connect peripherals such as ASCII terminals, printers, modems
Tape	Floppy disk on systems without a tape drive
Cylinder	Disk track

Figure 2. Pick Verbs

Verb	Function
COLOR	Sets colors on PC console
FDISK	Hard disk partitioner
LISTVERBS	List verbs in current account master dictionary
MSG	Send messages to other users
OFF	Log off the system
POWER-OFF	Flush RAM to disk for system shutdown
STARTPTR	Start a printer
TERM-TYPE	Establish ASCII terminal parameters
WHAT	Display current Pick/hardware configuration

One of Pick's unique features is dynamic memory management using a built-in virtual memory manager (VMM). Pick divides RAM into 512-byte frames. The VMM shuttles programs and data between disk and RAM, allowing the drive to be used as an extension of RAM. You cannot run out of memory unless you run out of disk space. The VMM's operation is transparent to the user.

Installation

DOS (prior to Version 3.2) doesn't care where it is installed on the disk. Pick, on the other hand, must be installed last. Pick automatically allocates its own disk partition to the last group of free and contiguous disk tracks that it locates during the booting process. The only control you have over how much space Pick allocates is to first allocate other disk partitions limiting the number of free tracks that Pick uses to install itself.

If DOS occupies the entire hard disk, the DOS partition must be backed up and moved to the outer (lower numbered) tracks before installing Pick. If Pick finds a large enough partition, it immediately begins to format the hard disk. After the operating

system files are loaded and transferred to the disk, the system displays the current hardware configuration, the number of drives, memory, microprocessor type, and port configuration. If a PC/AT system is configured for two hard disk drives, Pick installs itself on both drives, provided there are at least 2 MB of free space on the first drive. Once Pick is installed, disk-drive management is totally transparent to the user. Floppy-disk use is confined to system backups (FILE-SAVEs) and loading the Pick system or application software.

Pick supports the PC/AT clock and video controllers, such as MDA, CGA, and EGA. The peripheral installation guide provides information about Pick-supported peripherals, such as serial printers, multiport cards, modems, and tape backup systems. I don't recommend installing peripherals not discussed in the manual.

Installation of the Pick system took me about 20 minutes. Installation of 2 MB of application software took another 25 minutes.

Documentation

The Pick system is supplied with a PC-style User Reference Manual organized into sections on file structure, terminal control language, the editor, PROC language, ACCESS, Pick BASIC, etc. The ACCESS and Pick BASIC sections are the most detailed.

There are installation instructions for PC/XTs and PC/ATs. One pleasant surprise was a new peripheral installation guide. This section provided serial-port card configurations, an ASCII terminal wiring diagram, information on how to connect serial or parallel printers, modems, and tape backup units, and also insight into how Pick interacts with various hard-disk drives. I found this section one of the most informative parts of the manual.

One of the manual's sections is called a tutorial. To be more specific, it is really an ACCESS query language tutorial. What the manual lacks is detailed installation information and a "Getting Started With the Pick System" tutorial. Fortunately, there are a number of companies that sell Pick training products.

Verbs and Shells

Pick commands are entered under the control of the Terminal Control Language (TCL). After you log on, TCL displays a prompt and is ready to accept a command line of Pick verbs and options (Figure 2). Pick refers to commands as verbs. Each verb name is descriptive of its function. A verb may have one or more keywords called *verb options.*

To illustrate, the LISTFILES verb is used to display a list of disk files in the current account. The (PRT option is used with LISTFILES to output the disk directory to the printer. For example:

```
LISTFILES (PRT
```

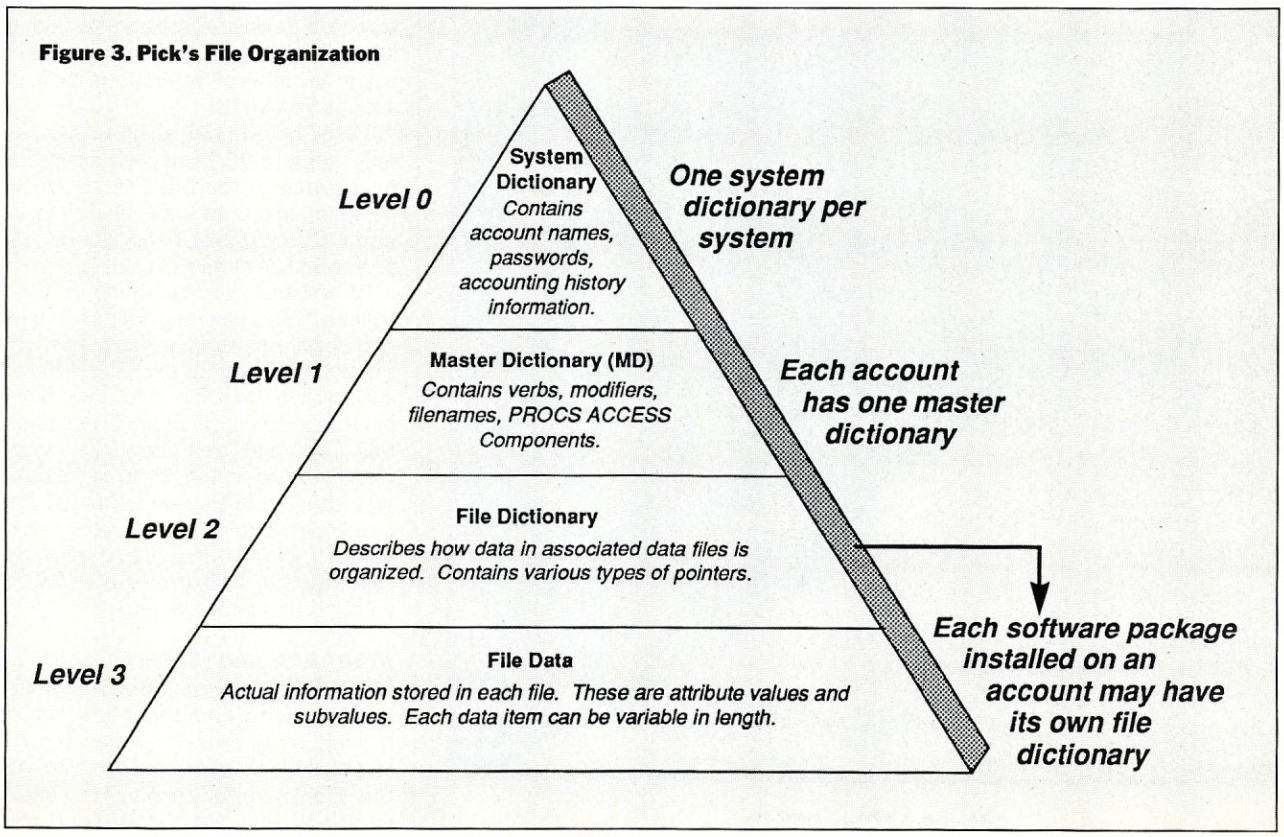
A line editor (EDITOR) and text formatter (RUNOFF) are included. RUNOFF allows customized formatting and printing of edited files. Although they can be used for routine word processing, I suggest using one of the optional dedicated Pick word processing programs such as JET (from JET Software), which is a full screen editor.

Pick provides a print spooler that, on the PC/AT, supports up to nine serial and three parallel printers. The spooler is started automatically each time the system is booted.

To facilitate its use, Pick contains the PROC high-level language. It allows programmers and experienced users to write PROCs that automatically execute TCL verbs, isolating novice users from the operating system via a series of menus. PROC is used extensively by many VARs and by Pick Systems to automate housekeeping functions and to reduce their software support time. The LISTFILES verb is an example of a PROC supplied by Pick that executes the ACCESS command required to generate a listing of disk files.

Programmers use PROC to define batch and interactive procedures in coordinating a series of program modules that comprise a software package. A PROC menu program may be created that is synonymous with an account name. Any person logging onto this account will be limited to performing the predetermined set of tasks specified by the menu. Programmers can tailor

Figure 3. Pick's File Organization


Level 0
System Dictionary
Contains account names, passwords, accounting history information.
One system dictionary per system
Level 1
Master Dictionary (MD)
Contains verbs, modifiers, filenames, PROCS ACCESS Components.
Each account has one master dictionary
Level 2
File Dictionary
Describes how data in associated data files is organized. Contains various types of pointers.
Level 3
File Data
Actual information stored in each file. These are attribute values and subvalues. Each data item can be variable in length.
Each software package installed on an account may have its own file dictionary

their application package to each client's needs and level of expertise. In my opinion, PROC is one of Pick's strongest features.

File System

Individual files contain two components: the *dictionary* and *data* portions. The Pick file system is hierarchical and has four levels in its structure numbered zero through three (Figure 3). The System Dictionary, level 0, is the highest level. There is one System Dictionary per system. The System Dictionary stores user account logon information, system security codes, and items used by SYSPROG.

The Master Dictionary defines the verbs that the user can execute and the files that the user can access. There is one Master Dictionary for each user account. The Master Dictionary provides a means of security because a Pick verb or program cannot be executed unless it is in the Master Dictionary.

The File Data Dictionary contains the criteria that define the structure of data files. File Data contains attribute values and subvalues. Pick's database capabilities stem from the interaction of File Data Dictionaries and the built-in ACCESS query language.

The ACCESS query language is Pick's report writer. To generate a report from an existing Pick data file, a command line, or *sentence*, is entered. A sentence consists of descriptive verbs (such as LIST or SORT) relational operators, Boolean operators, the name of the data file to be accessed, the items in the file to access, and print-formatting commands. Learning ACCESS requires the user to learn the vocabulary of verbs available in ACCESS. At first this task seems overwhelming, but once mastered, any type of report can be generated. Synonyms may also be defined for ACCESS, so that if a user feels more comfortable using SHOW instead of LIST, a synonym can be created in that user's dictionary. The synonym capability also makes it possible to customize a user's dictionary for a non-English language. Since each user has his own dictionary, other accounts will not be affected.

ACCESS is easy to learn, but using Pick alone as a data-entry system is inconvenient. The only means of entering data available to the user is the line-oriented editor. This is fine for programmers but difficult for users. Fortunately, applications software which is sold with Pick provides the proper user interface. This same software also provides the ability to select pre-formatted reports from menus. ACCESS gives you the ability to generate a report not on the menu.

Using Pick

One of the first things you learn is that Pick only accepts upper case command lines. Pick automatically places the IBM console in CAPS LOCK mode when the system is booted, but if you are working at a terminal you must place it in CAPS LOCK mode. When you log on as SYSPROG, the system informs you that supplemental documentation to the Pick User Reference Manual can be found in an ADDENDA item. I spent a few minutes browsing through the ADDENDA items and found a topic that gave me directions for how to configure Pick for various terminals. I used the EDITOR to modify the DICT.ACC file so that the system would default to the settings required of my terminal.

I then experimented with the ACCESS tutorial. Pick supplies an account, called TUTOR, which contains sample data files. I followed the directions for creating a file and then used the BUILD.DICT program to define the file's attributes. Once a file is created and its attributes are defined, you can use the EDITOR to add data items to the file. This is a poor substitute for the lack of a menu-driven or a full-screen file editor. Fortunately, adding data elements is usually accomplished using an optional application package such as Wizard III.

I used the EDITOR again to successfully apply a Pick-supplied programming patch to the DELETE-ACCOUNT program, and then I compiled the program. Every aspect I was able to test performed flawlessly.

As evidence of the need for user-friendly Pick systems, Fujitsu Microsystems of America has sidestepped the PC clone business in the United States and markets their PCs with Pick. They have done an excellent job of documenting Pick and have developed completely menu-driven Pick systems. I was loaned a Fujitsu 80286-based system to evaluate and was reluctant to return it. I spent more than a few hours exploring the Fujitsu menus and navigating through the system.

Multiuser and Multitasking

Pick is inherently multiuser and multitasking. One component of multitasking is the printer spooler. Since a terminal is not associated directly with the spooler, print spooling is considered a phantom or background pro-

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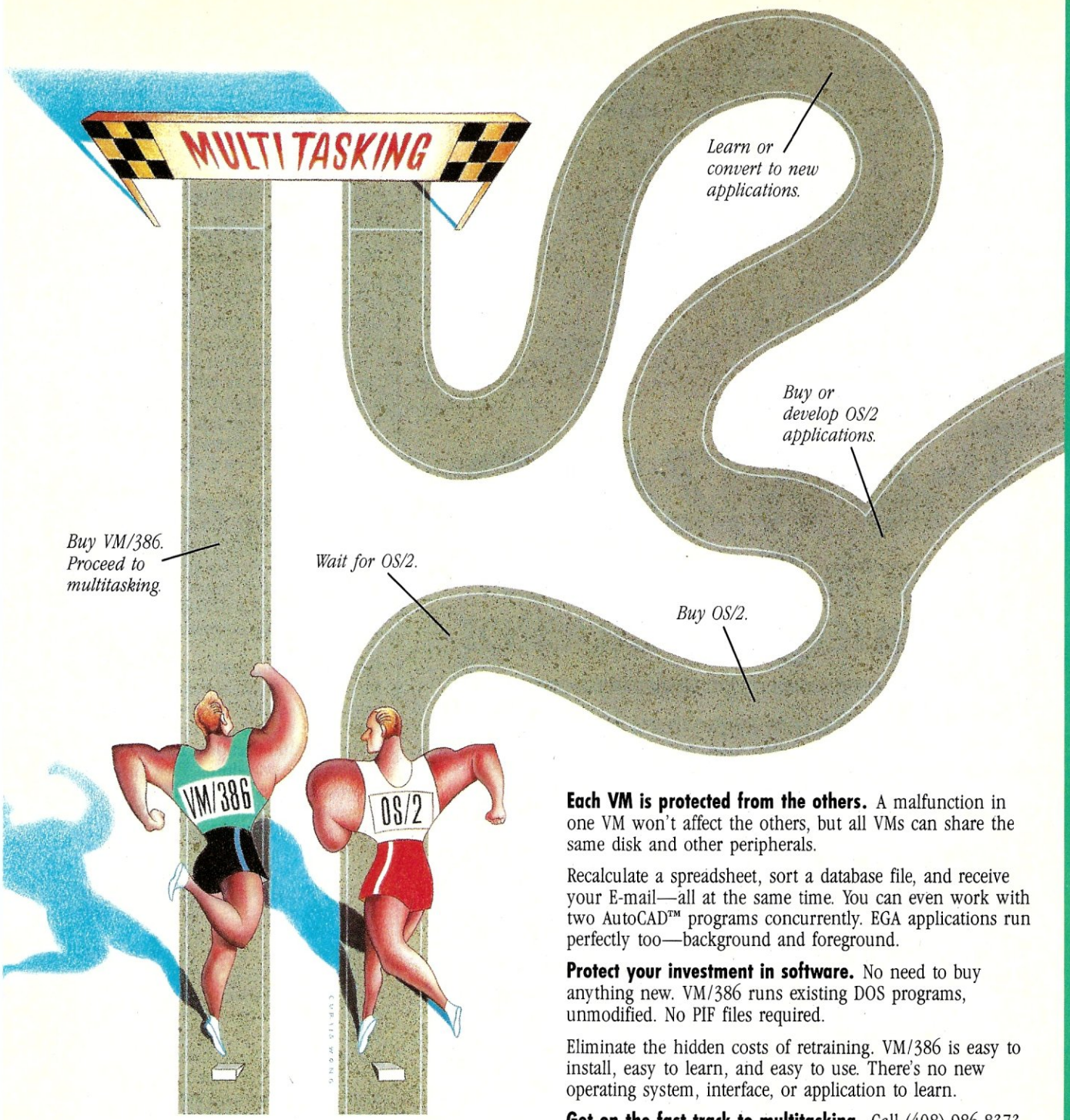

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cess. Other than the spooler, Pick considers multitasking an internal means of system-resource management. By prioritizing tasks, Pick automatically allocates-processor time slices, depending upon the type of task being executed. Interactive data-entry tasks are allocated the largest time slice, while batch-processing tasks, such as printing reports, are allocated the least amount of processor time. This allows for more efficient multiuser operation and minimizes system slowdown.

Multiuser operation and spooler startup are automatic at boot time. On a three-user PC/AT system, resources are allocated for the main console, two ASCII terminals, and a parallel printer.

Electronic Mail

Pick provides the ability to communicate with other users on the system via the MSG (message) verb. MSG sends messages to any terminal powered on and connected to the system. There are no provisions for storing messages.

DOS Compatibility

Although Pick and DOS can reside on the same disk, they cannot be executed concurrently. Pick has provided the COPYDOS and COPYPICK verbs to allow the exchange of files between Pick and DOS. COPYDOS reads and translates a DOS file into Pick format and stores it as an item in a Pick file. The COPYDOS verb can even use DOS path names.

COPYPICK translates a Pick file to DOS format and writes it to the DOS hard disk partition or to a DOS-formatted floppy disk. The file BRIDGE.EXE is the COPYPICK program and it must reside in the DOS partition.

I was able to move files in both directions using these programs. I would have appreciated a few more examples of how these programs could be used in a business application with popular DOS programs such as Lotus 1-2-3 or WordPerfect.

Fujitsu has developed Common Network Architecture (CNA) that permits connectivity with DOS-based systems. CNA allows a Fujitsu system running under Pick to network PCs running DOS using an RS-422 interface. Generic Pick lacks this feature.

System Administration

Most Pick systems have been sold by systems houses or VARs who have created a series of PROC menus to automate system operation, including routine backup procedures. Pick makes no provision for duplicate file entries or automatic backups. The ACCOUNT-SAVE verb is used to backup files on an individual account while the FILE-SAVE verb is used to backup the entire system. Since I had modified some files on my Pick system, I decided to perform a FILE-SAVE procedure.

Before performing either a FILE-SAVE or an ACCOUNT-SAVE procedure, you must estimate the number of disks required to store the data and format those disks. Although either of these procedures is easier to use than the DOS BACKUP command, I would have liked more informational messages displayed during the backup, particularly since backing up 2 MB worth of data takes 30 minutes using high-density floppy disks. The only way you know that something is happening is by watching the drive LED.

Programming Languages

The standard Pick application interface is Pick BASIC. Many Pick software developers feel that Pick BASIC is computationally complete, and that there is no need for other programming languages. A variety of business applications can be created using Pick BASIC. The system defines the rules for data management, and Pick BASIC provides the tools to manipulate the data. This creates a comfortable program-

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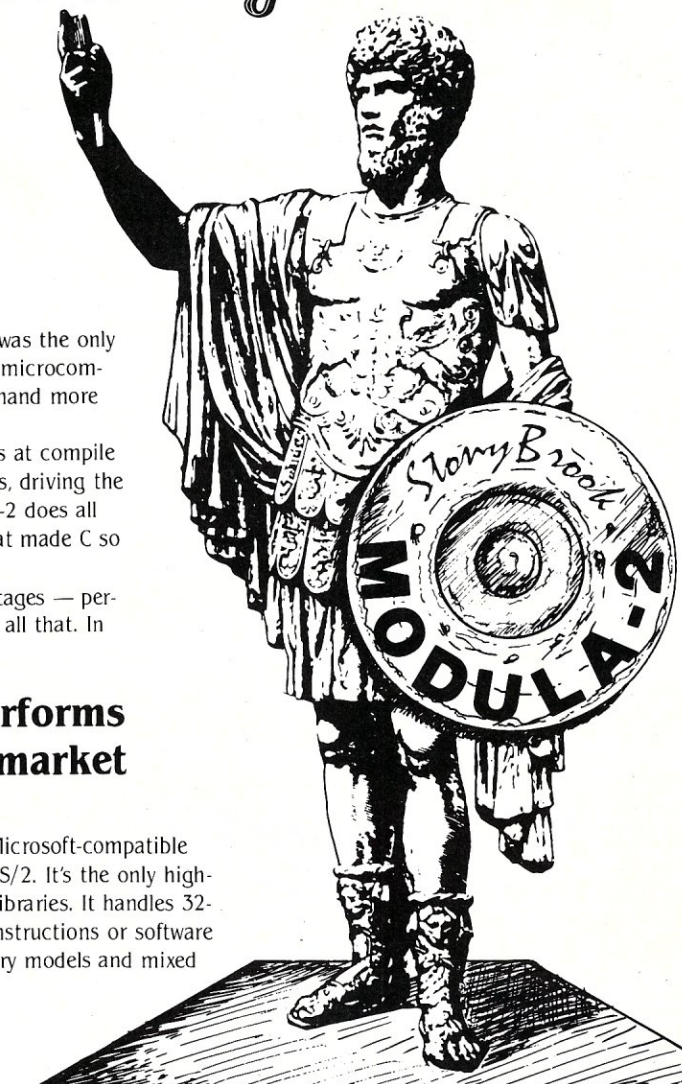
Circle Reader Service Number 74

I have come to bury C, sir, not to praise it.



C served us well in the days of kilobytes and kilohertz. It was the only language we could implement efficiently on our newborn microcomputers. But with today's mega-machines, shouldn't we demand more from our compilers?

Modula-2 increases productivity by catching your errors at compile time. You'll easily modularize and structure your programs, driving the hordes of barbaric bugs into the hinterlands. And Modula-2 does all this without taking away the low-level machine access that made C so popular.

Until now, you had to pay a price for the Modula-2 advantages — performance just didn't measure up to C. But we've changed all that. In a suite of benchmarks developed by PC Week:

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Stony Brook Modula-2, for 80x86 machines, produces Microsoft-compatible objects, and fully supports both Microsoft Windows and OS/2. It's the only high-level language compiler that lets you write dynamic link libraries. It handles 32- and 64-bit real numbers with in-line 80x87 coprocessor instructions or software emulation. And Stony Brook Modula-2 supports six memory models and mixed model programming.

You might want to bury your C compiler once you have used Stony Brook Modula-2, but you won't have to. We made it possible to directly call C and other languages from Modula-2, so you won't have to throw away your investment in C code.

So, friends, programmers, and C-users, lend us your ears. Call us or write for more information and to find out how you can get a demo compiler.

Benchmark	Stony Brook M-2 V1	Logitech M-2 V3	Turbo C V1	Microsoft C V4
Magnifier	0.05	0.06	0.05	0.05
For Loop	0.28	0.73	0.44	0.68
While Loop	0.35	0.75	0.49	0.66
Repeat Loop	0.33	0.68	0.38	0.66
Literal Assign	0.33	0.97	0.60	0.94
Memory Access	0.33	1.04	0.55	1.00
Real Arithmetic	4.68	13.40	3.73	2.96
Real Algebra	4.18	12.87	3.07	3.64
Vector	0.77	1.75	1.21	1.26
Equal If	0.66	1.47	0.93	1.32
Unequal If	0.66	1.43	0.99	1.32
No Parameters	0.33	0.60	0.34	1.04
Value	0.50	0.71	0.60	1.21
Reference	0.61	0.77	0.66	1.21
Real Maths	3.90	4.61	7.85	18.51

The compiler package includes DOS runtime library objects and full sources for our split-screen text editor for $195. The development package includes all of the above plus an automatic make utility, a symbolic debugger, and run-time library sources for $345. MasterCard and Visa accepted. Add $5 for shipping in North America, $25 for overseas shipping.

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Circle Reader Service Number 85

ming environment. If other languages were available, they would not have the facilities for dealing with Pick's unique data management system.

Support

Pick Systems provides telephone support for those who have a signed license agreement on file, although Pick encourages users to utilize its dealer network for support. Since I've been working with Pick over the past two years I've noticed an improvement in support. Pick Systems always returned my phone calls when unable to take my call immediately.

Pick World magazine is published quarterly ($25 per year) by Pick Systems and serves as a hardware and software buyers' guide and as a source for a variety of technical tips that address potential support topics; it also contains stories about how businesses use Pick. Updates and enhancements are announced in the magazine.

When I contacted Pick Systems to request an upgrade to the most current release of the operating system, I informed Pick Systems that I already had documentation from a previous release. I requested that they send only documentation revisions or supplements. Part of the new documentation I received was for the BASIC Programming Language section of the User Reference Manual. Unfortunately, the page numbering of this section was inconsistent with the rest of the manual and therefore had no index. When I spoke with Pick technical support, I was assured that this was an oversight on the part of the documentation staff.

Productivity Tools

Although there is no need for languages other than Pick BASIC, providing ways of increasing a programmer's productivity is always helpful. Wizard Software markets Wizard III to supplement the Pick operating system. Wizard transforms Pick into an easy-to-use menu-driven database management tool. I used Wizard to create PROC menus and to generate a simple database and print mailing labels. It can also be used to generate bug-free Pick BASIC code. Wizard Software also supplies software applications written using Wizard.

Summary

It is not surprising that Pick is sold primarily through VARs, because selling and supporting Pick requires a fair amount of expertise. Those who work in the Pick community swear by it because it offers multiuser features, it has a powerful built-in database manager and report writer, and—because of its implementation on computers ranging from PCs to mainframes—it allows users an unparalleled upgrade path.

My disappointment with Pick lies in its documentation. Any operating system, particularly one with Pick's complexity, must have documentation that is understandable and readable. Pick System's commitment to continuing the development and enhancement of its PC products suggests that the company is interested in attracting new and probably inexperienced users. Pick Systems should consider developing supplemental documentation.

I recommend the Pick operating system as a candidate for those who need multiuser capability and fast access to large databases. □

Walter Stagner is a systems consultant, author of several computer books, and a documentation writer. His interests include multiuser operating systems, application software evaluation, system installation, and training.

Did you find this article particularly useful? Circle number 8 on the reader service card.

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- Graphics on the PC
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- Troubleshooting Local Area Networks
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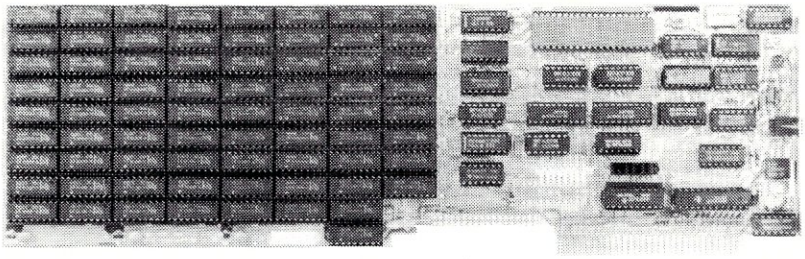

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Circle Reader Service Number 47

by Patrick H. Corrigan

LAN Standards

While talking with a new consulting client recently, the subject of standards came up. My client was a relatively new VAR firm specializing in installing legal office computer systems. They expressed their intention to only implement products that follow industry standards. Therefore, they intended to concentrate on Ethernet LANs, SQL databases, industry-standard word processors, and similar products.

This all seemed very logical, until they met the real world. One of the first systems they proposed required using existing single-pair phone lines for the LAN. In addition, a text database with the ability to index relatively large text files would be required. Unfortunately, although there are Ethernet products that run on twisted-pair phone wire, they require at least two pairs. In addition, while SQL databases hold the promise of transparent intersystem queries and a standard query and update language, they are not the best vehicle for text databases.

The point of the story is this: standards are fine, but we must understand what they are and where they are appropriate.

What are Standards?

Standards are agreements, pure and simple. In the United States, it is "standard" to drive on the right side of the road. One of the agreements we make when we obtain our driver's license is that we will adhere to this "standard." Is it necessarily better to drive on the right? The British and Japanese, who drive on the left, would probably say no. However, this standard allows us to maintain some semblance of order on our streets and highways. Also, there may be conditions where we can't or don't follow this "standard": a one-way street, a blocked lane, passing another vehicle, etc.

Standards in the LAN and data communication worlds are usually created to promote connectivity between products from different manufacturers. Theoretically, any device adhering to an industry standard should be able to communicate with any other device adhering to that same standard. Unfortunately, this is not always the case. For example, Ethernet is an accepted industry standard. Unfortunately, there are three separate and different Ethernet specifications. A product adhering to one specification may not necessarily be able to communicate with a product adhering to another specification. In addition, vendors often implement non-standard enhancements to their products.

Rather than promoting interconnection of different manufacturer's systems, some *de facto* "standards" may actually impede it. It has been argued that IBM's complex SNA (Systems Network Architecture) is designed to inhibit the connection of non-IBM equipment. Whether this was actually by design or merely by happenstance, many non-IBM systems have been effectively locked out of SNA.

How Are Standards Developed?

There are two primary categories of standards, sanctioned standards and *de facto* standards. An example of a sanctioned standard is the IEEE-696 standard for the S-100 expansion bus. An example of a *de facto* standard is the PC/AT expansion bus. Both are acknowledged standards, one by the agreement of a sanctioning body, one by the agreement of the user community. Which of these examples is "more standard"? By usage, the PC bus is. Which is better? All things considered, the S-100 bus is probably a superior design, but standards have nothing to do with quality or functionality.

De facto standards are developed in several ways: through the marketing clout of a particular manufacturer (the IBM PC bus, for example); by the informal agreement of the user community (for example, "Hayes-compatible" modems); by the agreement of vendors (ARCnet-compatible boards, for example, produced by more than 50 manufacturers worldwide); or by a combination of these.

Sanctioned standards, however, are almost always created by vendor clout. The 802.3 Ethernet standard was primarily the result of the combined efforts of Xerox, DEC, and Intel. The 802.5 Token-ring standard was the result of the clout wielded by IBM.

Although it happens rarely, standards can also be created by user groups. The MAP (Manufacturing Automation Protocol) standard has long been spearheaded by it biggest user, General Motors. The Department of Defense's TCP/IP (Transmission Control Protocol/Inter-network Protocol), which has been in existence for many years, is rapidly gaining acceptance as an effective way to interconnect dissimilar LANs and computer systems.

No Single Standard

"The thing I like about standards is that there are so many of them" is a quote attributed to several industry pundits. Because there are so many standards of both the sanctioned and *de facto* variety, another problem arises: "standard" products do not always work effectively with other "standard" products. In addition, products employing the same standard may not effectively work together. For example, Ethernet interfaces for dissimilar computers connect effectively at the hardware level, but without effective communication software (communications software is not part of the Ethernet standard) they will not work together.

> *"Standard" products do not always work effectively with other "standard" products.*

Using Standards Effectively

LAN standards are tools designed to make communication between systems easier. Unfortunately, they can become a means of avoiding responsibility for our decisions and actions—"It can't be my fault it doesn't work! I implemented an industry standard system!" Standards should be used to promote functionality, not impede it.

Standards change and evolve. Many products, systems, and standards employed today will be obsolete in three to five years (some are already obsolete!).

It is important to plan for change, even when (*especially* when) we don't know what those changes will be.

It is also very important to employ systems and standards appropriate for your environment. Remember, there are many standards to choose from, but not all are effective in all environments. For example, it is currently much easier to connect DEC systems with an Ethernet network than with an 802.5 Token-ring. On the other hand, the deterministic access scheme of a Token-passing network may be more appropriate for critical manufacturing control than the contention scheme of Ethernet.

Here are some examples of nonstandard solutions that are more appropriate than standard solutions:

Case 1. A company needs to create and transfer large graphics files (60 MB or more per file). In this situation, performance is a major issue and a high-speed, non-standard LAN, such as LANpac II from Racore (16 MB/sec., high-speed polling), or Pronet 80 from Proteon (80 MB/sec., token passing), would be more appropriate than a slower "standard" Token ring or Ethernet. In addition, the LAN operating system would have to accommodate volume sizes greater than 32 MB. Use of network operating systems based on DOS, such as the IBM's PC Network Program, would be difficult. Novell's NetWare or Univation's Lifenet, which both support much larger volumes, might offer a better solution.

Case 2. A company wants to install a LAN. The office was previously cabled for IBM 3270 terminals (this is RG-62 coax cable in a star or star-cluster configuration). Due to the design of the building, installing new cable would be prohibitively expensive. The existing RG-62 cabling cannot be used with any of the sanctioned standard LANs (Token ring, Ethernet, or Starlan), but can be used with ARCnet. Although not an officially recognized standard, ARCnet has a very large installed base and is widely supported by LAN operating system vendors.

Standards are designed to provide a common interface or methodology. If they assist you in getting the job done, fine. If they impede you, however, you should consider other approaches. □

Patrick H. Corrigan is a partner in The Corrigan Group—Information Services located in Corte Madera, California, an independent consulting firm specializing in the fields of local area networking, data communication, and office automation.

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Guidelines to Standards

1. Standards are agreements; nothing more, nothing less.
2. Standards should be employed to promote both functionality and flexibility, not inhibit them. If you have to choose between standardization and functionality, go with functionality.
3. There is no single standard, and even products adhering to a specific standard may not interface effectively.
4. Standards change. We live in a world where change is happening at an ever-increasing rate. Many of today's standards will be meaningless in three to five years.
5. Choose appropriate standards for your environment.

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by P. L. Olympia, Ph.D.

Standard Language And a Memory-Resident dBASE

A number of studies about the state of desktop computing in corporate America claim that the success of microcomputing in many organizations is due, in part, to in-house "PC gurus." These are people who are usually PC hobbyists, with no affiliation to the ADP or MIS departments, and who, by chance or design, ended up becoming the primary source of technical support for their departments. If you look around your department, chances are you will find one or two dBASE gurus who spend a lot of after-office hours teaching themselves to become proficient in dBASE and the use of PCs in general. But, did you ever wonder where these "gurus" go for assistance? They probably go to Ashton-Tate (dBASE's vendor) or a local dBASE user group.

Getting dBASE Help

Like most vendors, Ashton-Tate has a technical support group whose job is to answer questions about the company's products. (The phone call is at your expense.) The company also operates a very active conference, called ASHFORUM, on CompuServe. Questions posted in the conference elicit responses not only from the sysops (system operators) in charge of the service, but also from a number of experts around the country who dial in regularly. You don't need to pay to join the conference, but clearly, you must have a CompuServe account, a modem, and a communications program to access it. Finally, Ashton-Tate operates a little-known technical support bulletin board system at (213) 538-6196. The free BBS has eight lines but operates only at 300 and 1200 bits per second, at least as of this writing. The BBS has dBASE usage tips, electronic copies of TechNotes articles, and other files for downloading.

There are times when Ashton-Tate won't be able to answer dBASE questions to your satisfaction, such as questions on memo fields, undocumented features, and problems with interfacing to software with which dBASE is unfamiliar. Your best bet in finding answers to those kinds of questions may well be your local dBASE user group or a BBS operated by the group or its members. Generally speaking, user groups are staffed by volunteer members so the quality of support depends heavily on the quality of the group's membership. However, you get a more spirited discussion in a user group meeting where members speak freely from experience and are not hesitant to "tell it like it is." The relationship between vendors and user groups has always been symbiotic rather than adversarial, and it would be a rare vendor indeed that does not solicit feedback from user group members.

The International Dbase User Group

Viewed from the perspective of a major vendor, the logistics of dealing with local user groups is not always easy—there are just so many of them. It makes sense to have a much larger group that can serve as a coordinator for both vendors and local user groups. Such a group can also help encourage the discussion of issues with broad regional importance, for example, the issue of a standard Dbase language (more on this later).

A few months back, in this very column, I mentioned that some of us were discussing the idea of a national user group for dBASE. I am happy to report that the International Dbase User Group (IDBUG) became a reality on January 26, 1988, in New York. IDBUG is a non-profit organization established to provide a focal point for all users of the Dbase (not "dBASE") family of languages and associated products. IDBUG hopes to promote the effective exchange of ideas between users and vendors and encourage user participation in matters of regional or international concern. The organization expects to publish a quality journal with articles from contributors who are well-known in the Dbase community. It also expects to operate a multiline BBS with various product support conferences. I will serve as the founding president of the group. Other elected officers include Russ Freeland as vice president, Jordan Powell as secretary, and Pat Adams as treasurer. Initial funding for IDBUG comes from founding individual and corporate sponsors. For more information about the group, write to: IDBUG, 70A Greenwich Ave., Box 101, New York, NY 10011; (212) 597-2000.

A great deal of publicity has surrounded the formation and continuing activities of the so-called "dStandards Committee," a group dedicated to the implementation of a "Standard Dbase" language. The group has representation from major vendors of dBASE-like language compilers and add-on products. Notwithstanding the issue of whether the committee has, thus far, produced a draft language standard that makes sense, the goal of the committee is considered by many to be a worthwhile one. Users will benefit from the standardization of command syntax or usage, if not the command set itself. For example, people who now develop programs in Clipper and FoxBASE+ are frustrated by avoidable inconsistencies, such as whether an array variable should be defined with parenthesis as in FORTRAN, or square brackets as in C.

The dStandards Committee has been open and earnest about soliciting input from all quarters, and for that it deserves everyone's gratitude. However, there are those who doubt the Committee's long-term viability given that, so far, it does not have the support of Ashton-Tate. Perhaps the larger issue in the minds of many is whether a language standardization effort has a better chance of success if undertaken by a user group rather than by competing vendors, no matter how pure the group's goals may be. One of the first tasks of IDBUG is to help promote a standard Dbase language in an environment free of any shadows of conflicts of interest, be they real or imagined. Will we see a standard Dbase language someday? Only time will tell.

Take A Look At FrontRunner

If you haven't heard of FrontRunner yet, chances are you will soon. Ashton-Tate has just bought the distribution rights to it from its developer, Apex

Software Corporation, and reduced its price to $195. So what is FrontRunner? It is a dBASE-workalike that is distinguishable from other such products because it can be run as a memory-resident program as well as a regular, non-resident program. In memory-resident mode, FrontRunner gives you access to dBASE data and programs from within most applications. You can, of course, use it like a Sidekick on steroids—it is able to handle a Rolodex of unlimited size—but doing so barely exercises FrontRunner's extensive capabilities.

Since you can pop it from almost any applications, you can feed data to a currently running application with its PASTE command as though the data were typed at the keyboard. That takes care of programs that are unable to import data on their own, and it is also handy for such things as creating mail-merge letters with your favorite word processor. However, be forewarned that if your word processor happens to be Samna, FrontRunner or any TSR (terminate-and-stay-resident) program won't work as expected. The problem is, Samna has a bad habit of taking over the keyboard and won't let you call up any TSR programs via the hotkeys.

You can use FrontRunner like Sidekick on steroids—it is able to handle a Rolodex of unlimited size—but that would barely exercise its capabilities.

Write Your Own dBASE

With default sizes for file buffers and the like, FrontRunner uses about 157K of memory. Apex Software claims that this can be reduced by 64K if expanded memory (EMS) is available. I hesitate to call FrontRunner a "clone" because I estimate that it implements only about 80 percent of important dBASE features, commands, and functions (I suspect that increased compatibility may mean paying the price of using up more memory). That's not as bad as it sounds because, in fact, one of FrontRunner's most remarkable attributes is its extensibility. You can extend its command vocabulary simply by writing programs in the FrontRunner (dBASE) language.

Consider, for example, that the product's core vocabulary lacks the familiar commands like CREATE, EDIT, or BROWSE. To implement a BROWSE command, you would write a program BROWSE.PRG, which you would then compile to speed up operations. FrontRunner can compile programs and comes with a free run-time module. Then, with the SET SYNONYM command, you tell FrontRunner that whenever it is given the command BROWSE, it should execute the compiled program. Given this facility, it is reasonable to say that, depending on your programming ability, you can build your own version of dBASE using FrontRunner as your starter package.

Getting Data Into dBASE Applications

FrontRunner has a unique set of commands for manipulating files that makes it easy to get external data into the currently active dBASE application. To appreciate the power of these commands, let's first consider the traditional way of importing data into dBASE.

Say we want to write a disk catalog program in dBASE. Naturally, we will need to read the disk directories and somehow get the information, such as filenames, filedates, and filesizes, into our program. The easiest way to do that in dBASE (without writing BIN routines in assembly language or C) is to use what is called the "Scratch DBF" method. We define a scratch DBF file with only one field, a character field of, say, length 80. Using the dBASE RUN command, we can use DIR or another program to read the disk directory and redirect the output to a text file. Next, we load the text file into our scratch DBF via the APPEND . . . SDF command). Then our program examines each record of the DBF file and extracts from it the information that we want, e.g., filename.

Although the technique works, it is tedious and slow. Long ago, people like Andrew Schulman came up with a better technique for getting data into dBASE applications. In this instance, Andrew's MAKEMEM procedure will read the DIR text file output and from that create dBASE memory variables that the catalog program can access di-

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rectly. It is a clever technique that is much better than the "Scratch DBF" method. Andrew has also developed a program called MAKEDBF that allows a DBF file to be created on the fly and, of course, loaded with redirected data. Like MAKEMEM, MAKEDBF can be run in DOS without dBASE. MAKEMEM, MAKEDBF and related programs are some of the most outstanding values in the dBASE Shareware world. A contribution of $15 gets you not only the programs and excellent documentation, but also the C source code.

How FrontRunner Does It

With FrontRunner, writing applications such as a catalog program is a piece of cake because of its set of FILE commands. For example, FILE READ will read a file by line or by an arbitrary number of bytes. FILE WRITE is the complement command to write memory variable values to a file. The remarkable thing about these commands is that they work for both text and binary files, which means, for example, that you can create DBF files or write a dBASE/Lotus conversion program using only these commands.

External file manipulation has always been awkward in dBASE. FrontRunner gives you direct file control just like traditional languages such as BASIC or C. Along with FrontRunner's other excellent features, such as memory-residency, extensibility, windowing, and a debugging facility, the file functions serve as attractive icing on an already feature-laden cake. □

External file manipulation has always been awkward in dBASE. FrontRunner gives you direct file control just like traditional languages such as BASIC or C.

P. L. Olympia, Ph.D. is a scientist with a doctorate in Chemical Physics. He is better known as "Dr. dBASE." He is coauthor of a book, dBASE Power: Building and Using Programming Tools, *published by Ashton-Tate.*

Did you find this article particularly useful? Circle number 10 on the reader service card.

Product Information

FrontRunner, Version 1.2
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Online tutorial	Yes	No	No	Yes
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Continued from page 33
run a MultiLink utility program immediately beforehand to let MultiLink know that an interrupt-driven communications program would be run. With a shielded null modem cable connecting two computers, error-free XMODEM file transfers could be made at 57,600 baud using my built-in serial port.

Because of MultiLink's method of swapping 80286 extended memory around, it can't coexist with other software that also uses extended memory, such as VDISK with the /E option. But its own RAM disk driver is supplied that has the advantage of running faster than the original since it does not have to switch the CPU in and out of protected mode.

Other supplied utilities tend to make your system a pleasure to use. QUICKVID.SYS noticeably speeds up the console output of programs that do not write directly to the video buffer. MLCACHE.SYS buffers disk sectors in extended memory so that when accessed a subsequent time, the disk read takes place at RAM disk speed. With a 1 megabyte disk cache, I found that the lowest partition's memory only decreased by about 3K while disk hogs, such as dBASE III+, could be reloaded in each partition without the hard disk light ever coming on. My only gripe here is that MLCACHE adheres to the conservative approach of always writing through the buffer. It would be nice to provide options, such as buffering disk writes or locking specified overlays into the cache. Nonetheless, these utilities make the AT Gizmo an attractive product, even without MultiLink.

The Manual

The MultiLink manual is of the high-gloss variety and comes in the common nine-by-six-inch slip cover that doubles as a book stand. The manual comes complete with table of contents and index and this manual seems to be written for the most elementary users. More experienced users may become impatient wading through some of its extended explanations.

My only substantive criticism of the MultiLink manual concerns its multiprocessing terminology. The partition mapped lowest in memory is always referred to as the foreground partition and all other partitions are referred to as background partitions without regard for which partition owns the real console. This terminology can be confusing.

The AT Gizmo board is supplied with its own manual. It is filled with "by-the-numbers" illustrations of how to move the CPU with a step-by-step approach reminiscent of Heathkit assembly instructions. Separate instructions are provided for the two common varieties of 286 packaging: the 132-pin package used in the IBM as well as the more easily manipulated, leadless flat pack used in the Compaq and other clones.

Limitations

I did encounter a few glitches while using MultiLink. I found some minor cursor positioning errors that occasionally occurred when swapping between partitions. Fortunately, the cursor would snap back to the correct position at the first keystroke.

The concept of using serial terminals with software that does direct-screen I/O does have its limits. With an 80286 running at 8 megahertz and terminals running at 38,400 baud, performance running Lotus would be good but couldn't compare to running SuperCalc installed specifically for the same terminal, as is usual under Concurrent PC-DOS. This is because there is just no way a line insert done directly in the video buffer can be distinguished from redrawing a portion of the screen. MultiLink has no opportunity to take advantage of line and character insert and delete commands that terminal-specific software uses to avoid pushing large chunks of the screen through the serial port. The real problem is that software with terminal-specific installation options is becoming increasingly rare in the PC marketplace. To MultiLink's credit, it makes the best of the situation, using the terminal's cursor positioning commands to only rewrite those portions of the screen that are changed in the video buffer, complete with terminal-supported attributes.

A major weakness of MultiLink is that users are given only a minimum of protection from each other. Nothing resembling UNIX's passworded file and directory access exists in MultiLink. The MultiLink semaphore system is totally voluntary. You have to trust your users. If more than one user tries to edit the same file at the same time without any precautions, one of them is going to lose their work. Similar problems can occur when users in the same directory delete files or run multiple copies of programs that use the same name for temporary files. Since running single-user applications in a multiuser environment is not a completely solvable problem, the best approach is to plan carefully and choose NetBIOS compatible software whenever possible.

A more serious shortcoming is MultiLink's inability to protect itself from programs that don't make any attempt to find out how much system memory there is before writing to it. This seems to be a conscious decision on the part of Software Link to keep memory management simple and not try to duplicate all the features of 286 protected-mode operation. Programs written for DOS 1.x pose the real threat of hanging a partition. And when this happens, there is no way to abort the errant program or reset the partition without disturbing the others. All one can do is abandon the partition until the system is reset.

The only program that I encountered that totally hung the system is Norton's SI version 3.10. Fastback occasionally hung the computer when backing up to 1.2-megabyte floppies, but Ctrl-C was still able to abort backup.

Conclusion

MultiLink is a viable product that accomplishes what it sets out to do. As long as terminals with MultiLink remain less expensive than networked PCs, it will be a cost-effective alternative for those who require shared microcomputer access to applications employing direct video console output. The practicality of the MultiLink approach will be determined largely by the skill in which a user organizes his system and chooses the application packages to run with it.

MultiLink makes unique use of 80286 extended memory, effectively bank-switching the entire memory space, including memory soldered to the motherboard. With the hardware assistance of the AT Gizmo memory management unit, it efficiently performs multiprocessing and delivers multiuser capabilities considered by many to be solely within the province of the 80386 protected-mode operating systems of the future. □

Howard Vigorita is an attorney on the staff of the United States District Court in New York. He also serves as vice president of the New York Amateur Computer Club.

Did you find this article particularly useful? Circle number 4 on the reader service card.

Product Information

MultiLink Advanced	$595
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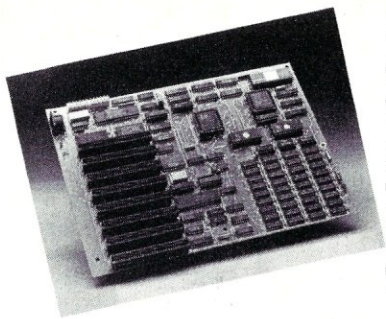

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New Software Products

Turbo 4 Source Code Generator Imported from Holland

DSA Software has released a source code generator for Turbo Pascal Version 4.0. The first part of this programming tool provides a screen-oriented, comprehensive, procedural language with simply defined file definitions, data entry programs, screens, and configurations. The resulting parameter code is fully transportable between different computer systems and compilers. Mainframe software can be prepared, compiled, and then tested on PCs. The second half of the DSA package is an automatic program generator that delivers 20 lines of code per second on a standard PC/XT.

The single version of the DSA Source Generator contains a manual and seven diskettes, and sells for $2750 in the single-user version. For more information, contact the North American distributor, Advice Bureau International Inc., 2734 Evans Dale Circle, Atlanta, GA 30340; (404) 496-5781.

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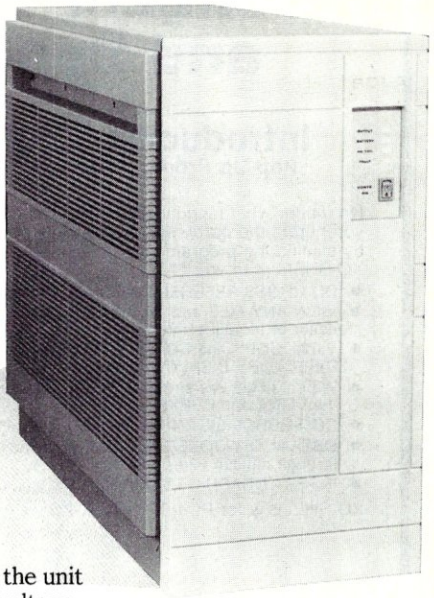

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The ESI-2041A ShareSpool retails for $495. For more information, contact **Extended Systems**, 6062 Morris Hill, Boise, ID 83711; (208) 322-7163.

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DSA's Turbo Pascal 4.0 source code generator.

PC-Compatible Products

Software Link Adds Multiple Parallel Port Board

The Software Link has released ParaPort, an IBM-compatible parallel four-port board designed to run with LANLink 5X, the company's software-based LAN. When run with LANLink 5X, users have access to up to 16 parallel connections at a half-megabit per second. A typical configuration would use the ParaPort card with a LANLink 5X-based system with a 286- or 386-based machine acting as a non-dedicated file server. ParaPort also can be used as a multiple printer port board. The board uses a proprietary cabling scheme that supports a bidirectional flow of data.

The ParaPort is available for $495. For more information, contact **The Software Link, Inc.**, 3577 Parkway Lane, Norcross, GA 30092; (404) 448-5465.

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"Best quality emitted code by any compiler I've encountered. Often amazing." **Bill Ferguson, Fox Software — FoxBase (386).**

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- **High C ™:**

Computer Language	February 1986, '87	
Dr. Dobb's Journal	August 1986	
PC Magazine	Jan. 27, 1987	(80386 version)
Dr. Dobb's Journal	July 1987	(80386 version)
BYTE Magazine	November 1987	(80386 version)

- **Professional Pascal ™:**

PC Magazine	Dec. 29, 1985	
Computer Language	May 1986	
PC Tech Journal	July 1986	
Journal of Pascal, Ada, & Modula-2	Nov.-Dec. 1986	
BYTE Magazine	Dec. '86, June '87	(80386 version)

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The Clear Choice for Large Programming Projects — PC Tech J.

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Classifieds

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All the computer listings printed in *Micro/Systems* are available on MS-DOS floppy disk. Programs from each issue are available for $14.95 each. For more information, contact:

Tim Trickett
M&T Books
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Redwood City, CA 94063
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PC/XT Clock No-Slot Modules, & PCjr Clock Cartridge. INTEGRITY TECHNOLOGY, 105 Serra, #230, Milpitas, CA 95035.

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Extremely fast Sort/Merge utility. Run as a DOS command or CALL as a subroutine from 40 programming languages. Unlimited filesize, multiple key fields, record selection and much more! Call or write for more info. $149. Opt-Tech, P.O. Box 678, Zephyr Cove, NV 89448; (702) 588-3737.

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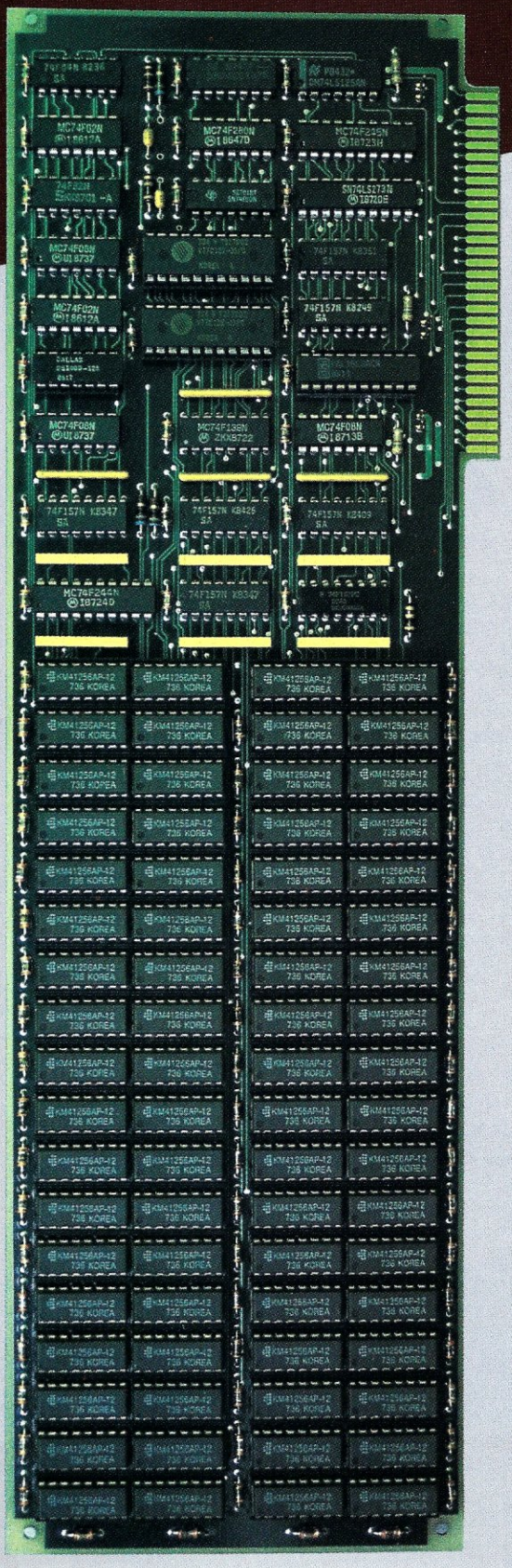
X-BANDIT

Designed for the EMS 4.0 Standard



DESIGN PHILOSOPHY

• The Teletek X-Bandit was specifically designed to utilize the advanced features of the Lotus/Intel/Microsoft EMS 4.0 Specification. It is available in both 8 and 16 bit versions for use in the IBM XT, AT, and compatibles.

MEMORY

• Segmented Memory Mapping allows the user to fill out unused memory segments between 640K and 1 Megabyte.

• Split Memory Addressing allows the user to fill out conventional memory to 640K.

• Extended Memory Addressing is available for the PC/AT version.

• 2 MB capacity in a single slot. Up to 8 MB per system.

• Parity checking.

SOFTWARE

• Easy menu-driven auto configuration software.

• Device driver includes print spooler and RAM drive.

• Supports multitasking with the appropriate shell-resident software package.

SPEED

• 6/8/10/12 MHz speed with 0 wait states. 16 MHz speed with 1 wait state.

WARRANTY

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TELETEK

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Sacramento, CA 95838
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Our famous customers are a little camera shy. It's not that they are embarrassed by being Essential C Utility Library users. They just don't want us shouting their names from the roof tops.

The prestige of our users is not the primary reason to buy the Essential C Utility Library. The increased speed, features, and size efficiency of our products are the factors that demand their use. Our library contains *over 400 functions,* all designed with elegance in mind.

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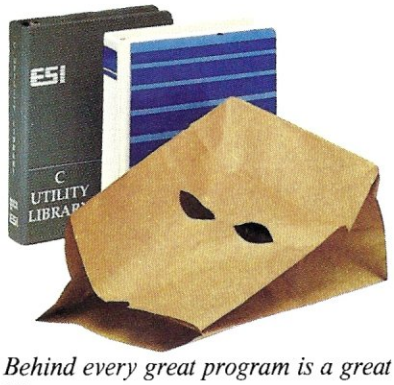


Behind every great program is a great library.

Functions At A Glance

- Fastest screen output available.
- Save/Restore color screens in 1/10 sec.
- Pop-up block cursor menus
- Save/Restore windows to disk or memory
- 50 functions for business graphics
- dozens of string formats
- time and date arithmetic
- julian and day-of-week
- Ctrl-Break key trapping
- Field oriented data entry
- Stuff keyboard buffer
- 18 Mouse control functions
- Execute programs and batch files
- Disk error trapping
- Determine space available
- 40 functions to process characters and words
- Insert, delete, extract, index, translate
- Tested, easy-to-follow examples
- Demo programs with source code
- All source code included

Documentation:
Thorough, comprehensive, 260 pages

Compatible C Compilers:
Microsoft, Lattice, Computer Innovations, Aztec, Mark Williams, DeSmet, and Wizard

$185.00

Do Your Homework

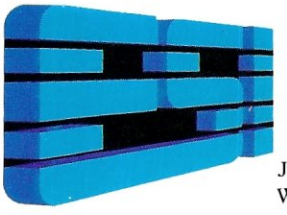
The library you buy can influence the rest of your programming life. We encourage you to do some checking before making a decision. When you've done your homework, you'll choose Essential. Call our support staff of experienced C programmers and find out before you buy how things will be after your check clears.

What's a Library Without a Librarian?

Our library comes complete with a sophisticated source code librarian. Now you can maintain current versions and conserve disk space. We want your development work to go as smoothly as possible.

No Royalties, 30 Day Guarantee

If within 30 days you don't find our library totally satisfactory, bag the whole thing and receive a complete refund. There are no royalties associated with the library.



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